DURAStar HYBRID

DIESEL HYBRID COMMERCIAL TRUCK SEMINAR

Josh Lepage
Sales Manager – Hybrid Vocational Sales

October 23, 2008

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HYBRID TECHNOLOGY

Agenda

- Overview & International Hybrid History
- Diamond Logic Electrical System
- Fuel Economy Improvements
- Eaton Hybrid System
- Application Coverage Production Release
- Hybrid System Description & Operation
- Tax Credits & Grant Incentives
- Business Case & Pricing
- 2010 Emission Strategy

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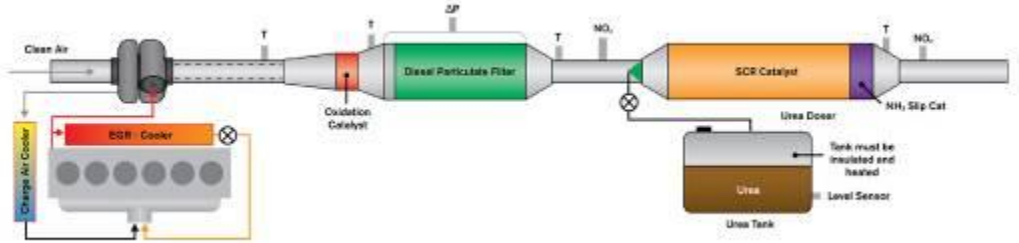
Heavy Duty Truck Industry Facts

- Class 3-8 commercial vehicles use 25% of the fuel used by the US for ground transportation industry
- Fuel economy improvement and 2010 emissions strategy are currently the focus R&D areas for all Truck OEM
- Emission and fuel reduction benefits of Hybrid Technology are well accepted by the industry



HYBRID TECHNOLOGY

Corporate Responsibility

- Reduced dependence on fossil fuels
- Reduction in green house gases
  - –CO2 Emissions
- International's® Green Diesel Hybrid Technology

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Why Hybrid Trucks?

- Impacts on the future of diesel transportation
  - Environmental issues
  - Energy issues
    - Fuel efficiency
    - Climate change
    - Clean air

Up to 60% more fuel economy with e-PTO

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HYBRID TECHNOLOGY

International Path Towards Hybridization

1996
- Two-concept truck development utilizing EV industry-available components

1998
- Multiple application truck evaluation

2001
- Awarded DOE contract

2003
- Designed and produced UPS validation unit

2004
- Designed and produced 4200 validation unit with I4
- 24 pre-production HTUF utility vehicles

2005
- Awarded contract for 115 Pureolater vans using Workhorse Chassis
- EPA Crada for Series HH UPS Vehicles
- Eaton HLA for Parallel Refuse Vehicle

2006
- Product release HE Utility Vehicle. Received order for 100 Vehicles
- Preproduction HE School Bus
- Hybrid Electric FTTS Vehicle for DOD

2007
- UPS & Frito Lay Strip Chassis (25 vehicles)
- Production Release Hybrid School Bus
- HEV Shuttle Bus

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HYBRID TECHNOLOGY

History

Hybrid

Truck

Users

Forum

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History

Hybrid Power Systems

- July 2004
- HTUF Utility Working Group select Eaton, International, and Altec
- Pre-Production unit orders

Altec HYBRID

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HTUF Hybrid Program

- 24 trucks in service for field trial in 2006
- Trucks are equipped with Eaton's hybrid electric system, complete with electric-PTO and auxiliary power generation
- 14 utility fleets involved in the program
- 40% to 60% Fuels Savings Measured

http:// www.calstart.org/programs/htuf/

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What Makes The System Work?

- Eaton Hybrid Electric Power Train
  - Hybrid drive system components
- International® Diamond Logic ® Electrical System
  - Complete electronic vehicle integration
  - Optimization body of functions

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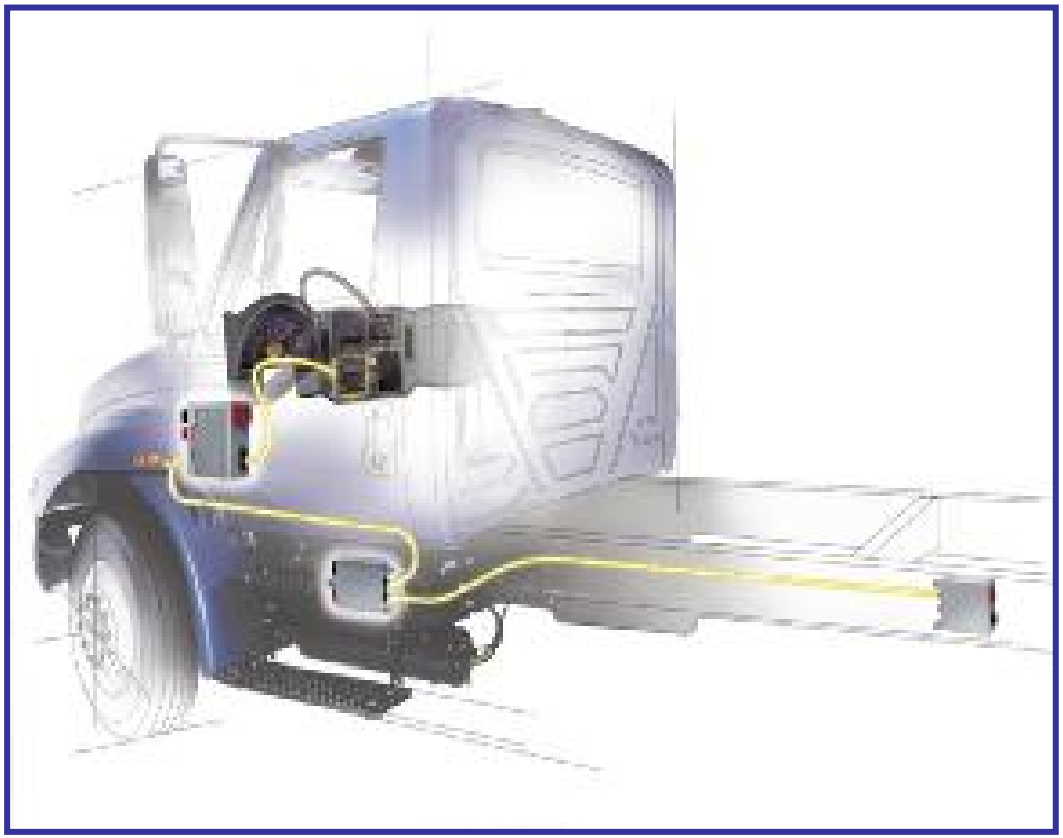
LEADING TECHNOLOGY =



Industries
First
“Smart Truck”

Best In Class

Smart Truck Technology

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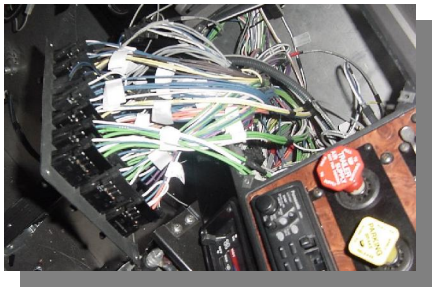
We Have Come A Long Way!

Hard Wired Switches



Multiplexed Switches

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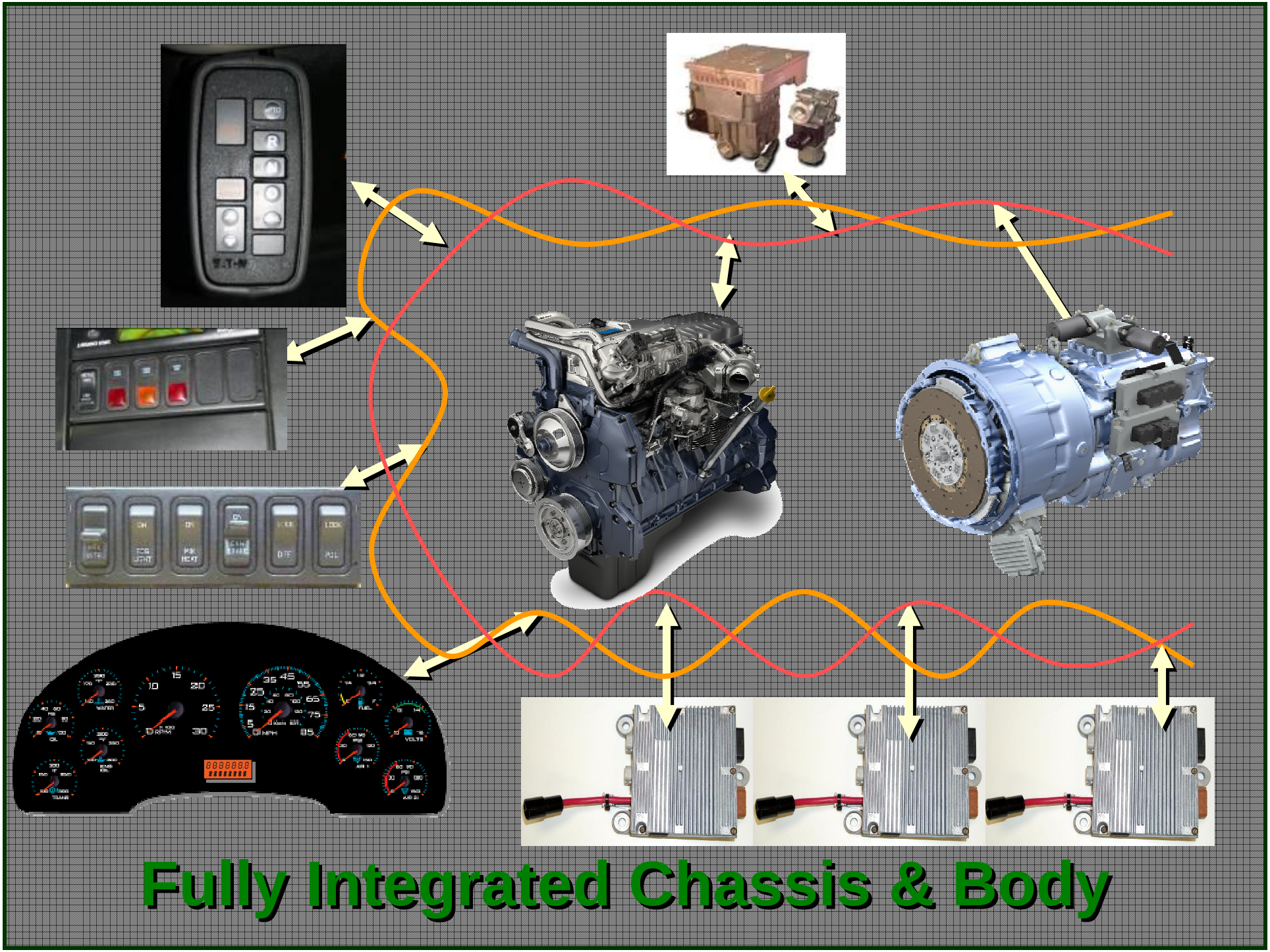
Fully Integrated Chassis & Body

Hybrid Chassis and Body Integration

Diamond Logic® is the key to body / chassis integration.

- Full J-1939 Communications - entire vehicle
- Full diagnostics & system communication
- Optimization of e-PTO system w/engine off
- Fuel economy – system time-outs
- Chassis body equipment interlocks
  - Protect equipment
  - Protect operators
- Body equipment customization

HYBRID TECHNOLOGY

Fuel Economy Improvements

- **Keys to Improvements**
  - **Intercity Application Critical**
  - **Regenerative Braking**
  - **Idle Reduction**
- **Expectations**
  - **Hybrid Base System 30 to 40% Improvement in Fuel Economy**
    - **Pickup & Delivery Applications**
  - **Reduced Emissions**
  - **Reduced Maintenance**
  - **Bio-diesel Approved (B-20)**
  - **Hybrid E-PTO system 40-60% Improvement in Fuel Economy**
    - **Utility Application**

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The only way you can reduce Greenhouse Gases is not burn the fuel!

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Fuel Saved – Emissions Reduced

On 2006 Emissions Engines

Dollars & Gallons of Fuel Saved Annually

Hybrid Car*

$686 *[1]
138 Gallons
12,500 Miles

P&D

~ 600-900 Gallons Saved
6.6 – 9.9 Tons of CO2 Reduced

20,000 Miles ~ $2,370 to $3,555 *[2]

~ 1,000-1,500 Gallons Saved
11 – 16.5 Tons of CO2 Reduced

12,000 Miles | 3 hrs / day Work-site Ops ~ $3,950 to $5,925 *[2,3]

Utility

~ 1,200-1,900 Gallons Saved
13.2 – 21 Tons of CO2 Reduced

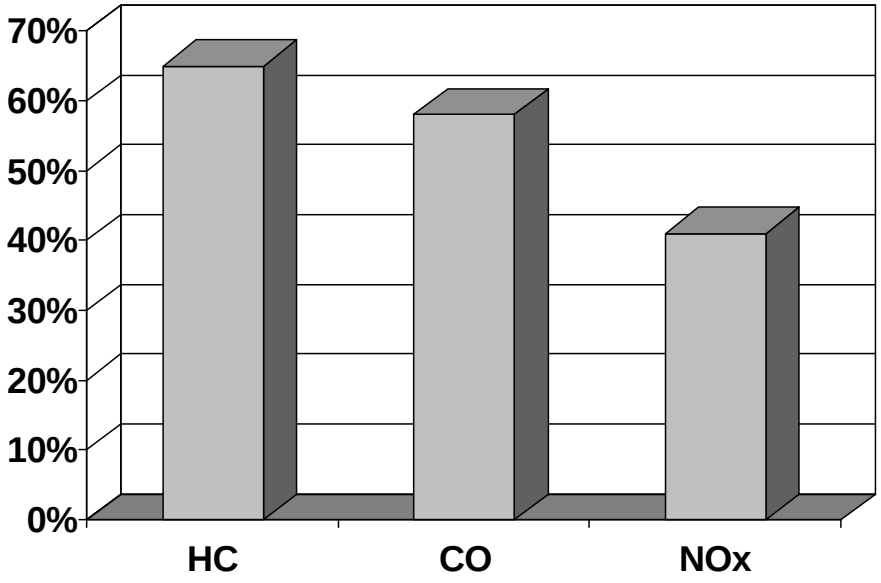
9,500 Miles | 6 hrs / day Work-site Ops

~ $4,740 to $7,505 *[2,3]

Over the Road
Engine off work-site

*[1] Assume $3.75 gal; 21mpg; 30% improvement
*[2] $3.95/gallon fuel
*[3] Assume baseline: 7.5 mpg & 1.18 gph idle

Utility Truck Emissions Reduced**



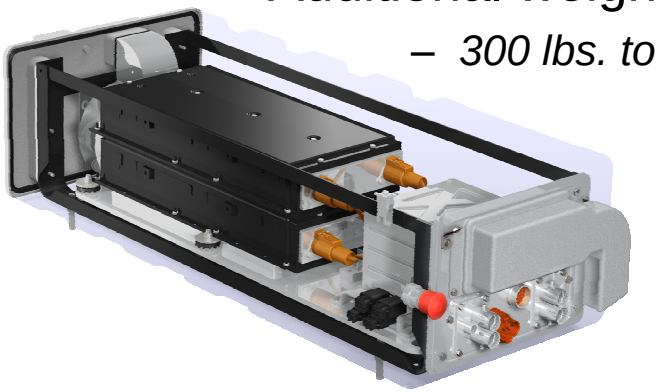
Over the road & Worksite Ops

** Based on independent 3rd party testing

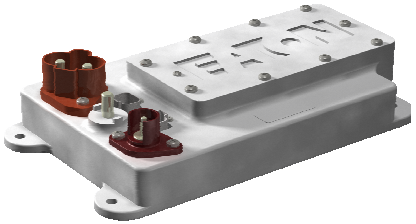
P&D – 30-50% fuel economy improvement
Utility – 40-60% fuel consumption reduction

Primary Hybrid Components

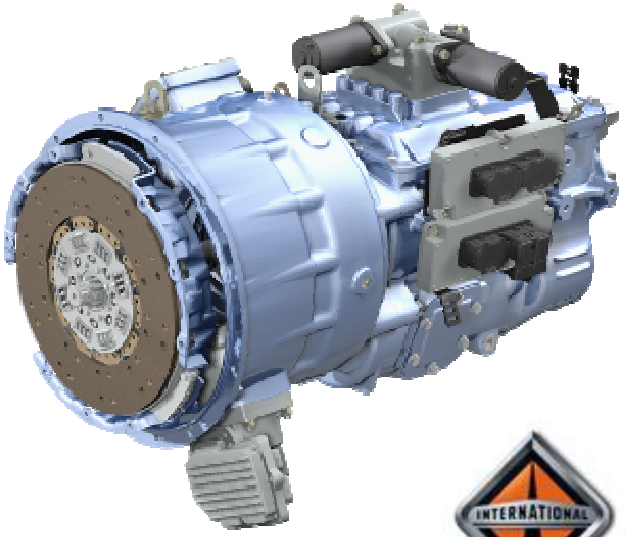
- Maximize payload weight and space
  - Additional weight of hybrid related components is ~450 lbs.
    - *300 lbs. to the front axle*



Power Electronics Carrier (Battery Box)



DC/DC Converter



Hybrid Drive Unit (HDU)

Motor Inverter/Controller

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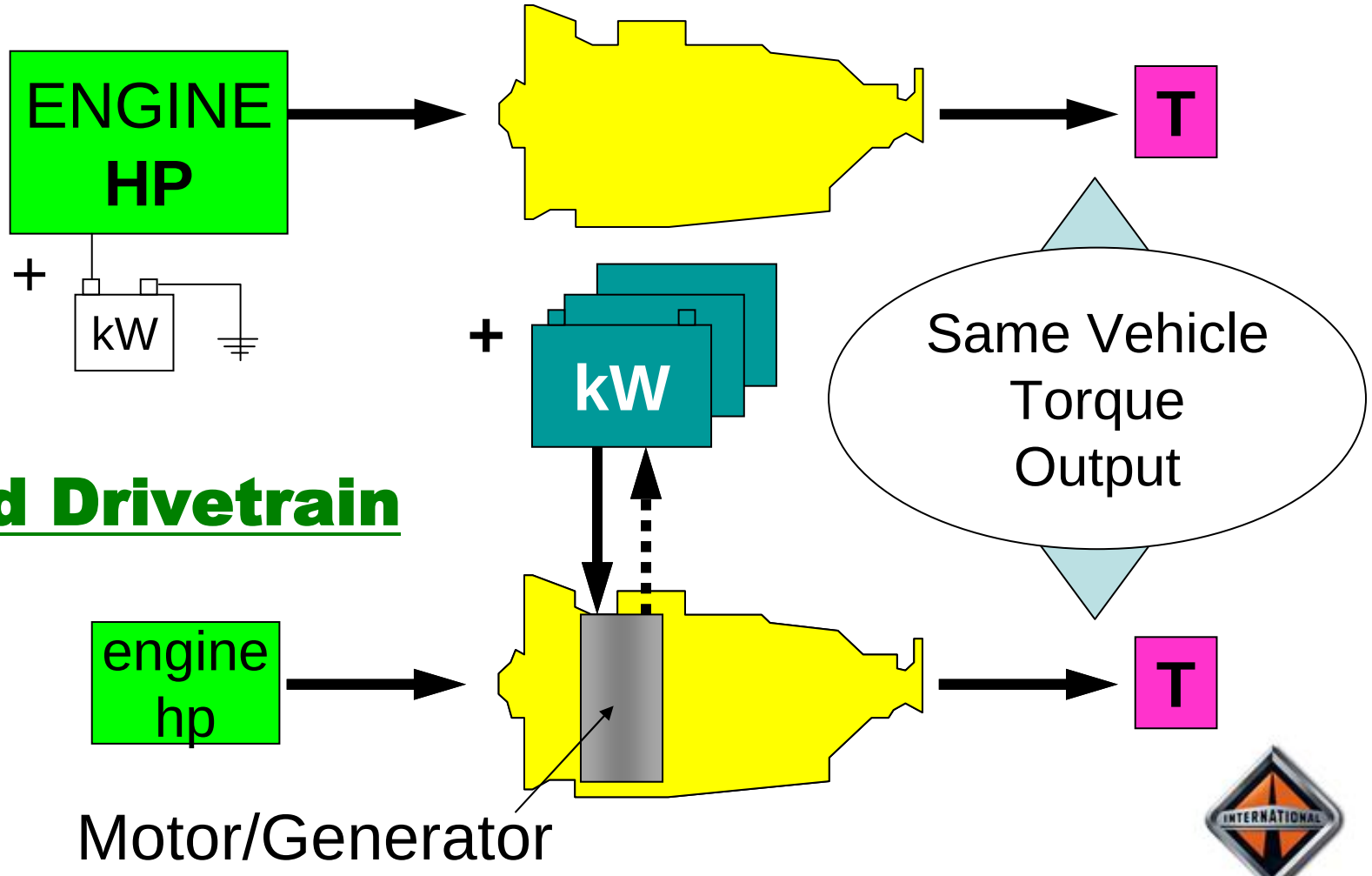
Traditional Drivetrain



Hybrid Drivetrain

Mild Parallel Hybrid System Pre-Transmission

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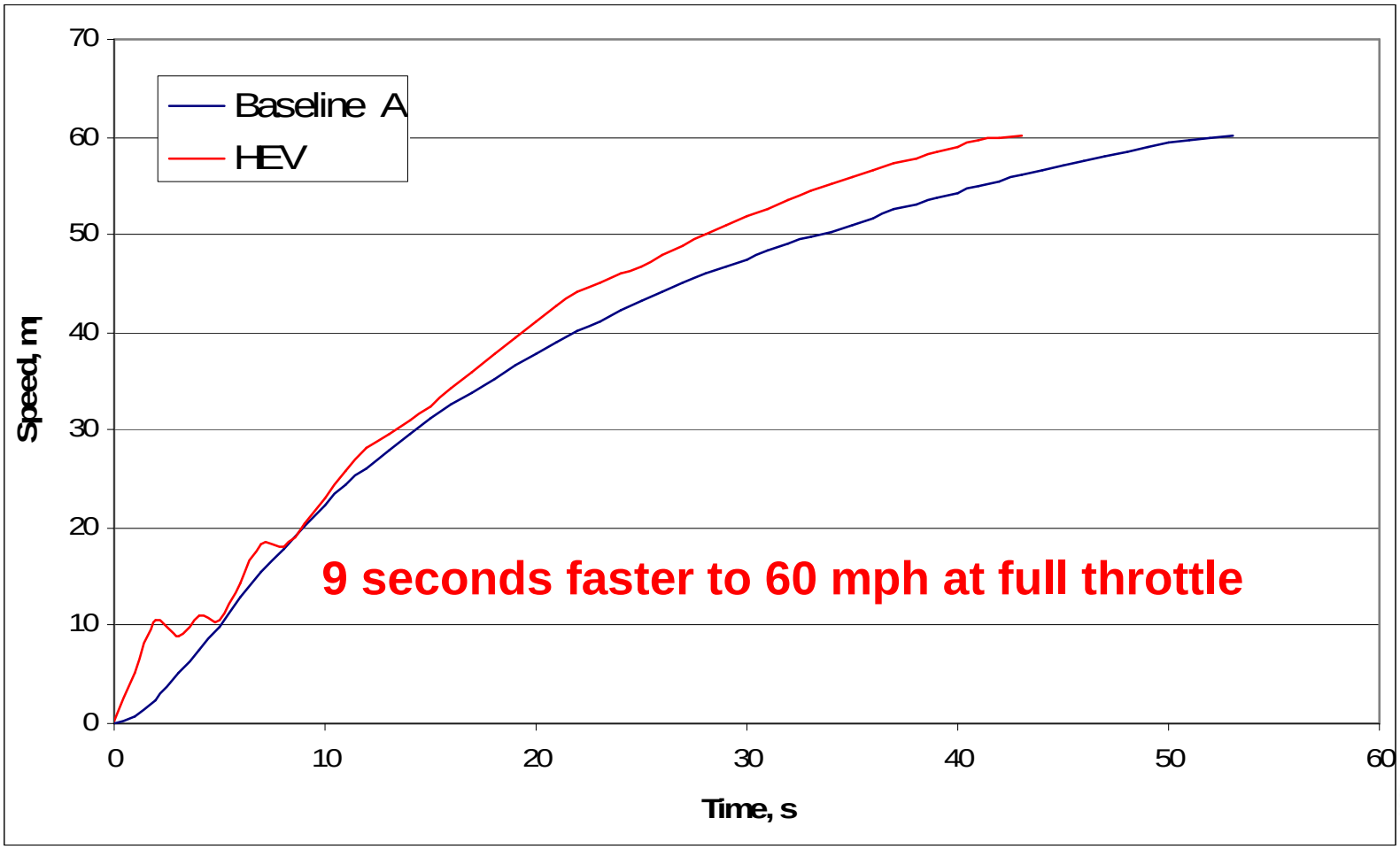
0-60 Acceleration



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Application Coverage

23,500# to 37,000# GVW

- Base System
  - •Pickup & Delivery
  - •Landscape Dump
  - •Shuttle Bus
  - •Beverage
  - •Stake Flat
  - •Armored Car
  - •Expediter
  - **•Tractor (55,000# GCW)**

- ePTO System
  - •Utility/Aerial Bucket
  - •Tree Trimmer / Crane
  - •Recovery Vehicle
  - •Road Patch Truck

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HYBRID TECHNOLOGY

Power Train Features

Current 2007 MaxxForce DT engine ratings approved for use with Eaton's Medium Duty Automated Transmissions include:

- **210HP/560ft-lb (New)**
- **225HP/620ft-lb (Current)**
- **225HP/560ft-lb (Current)**
- **230HP/620ft-lb (New)**
- **245HP/620ft-lb (New)**
- **255HP/660ft-lb (New)**

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Production Released

- Exhaust after treatment options:
  - RH horz/horz,
  - RH under cab horz,
  - RH horz./vertical tailpipe
- Cruise control availability
- New vanity cover for PEC

Vehicle feature requirements

- Air brakes
- 22.5” Wheels
- On/off fan drive
- Up to 33,000 GCWR

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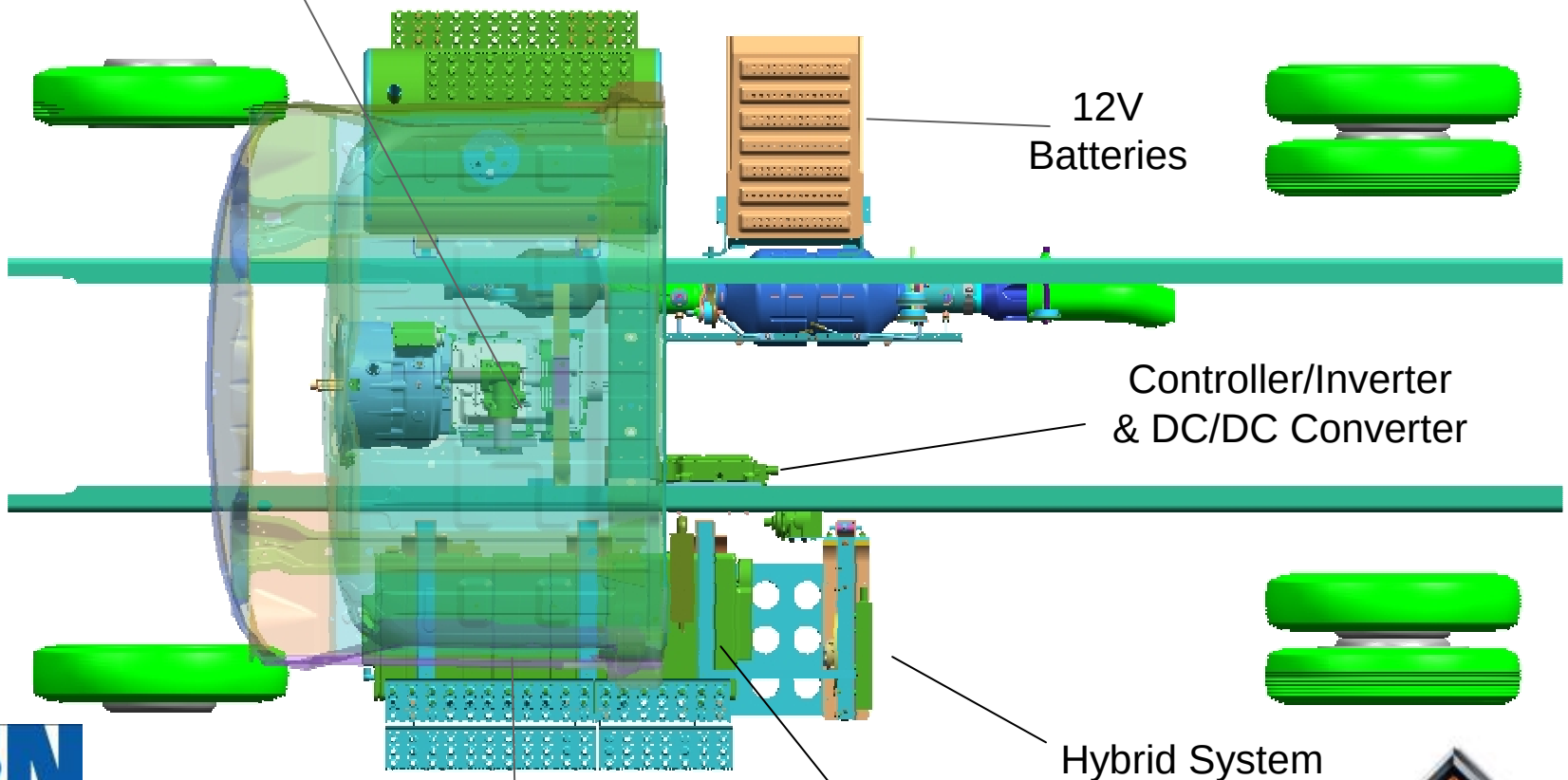
Hybrid System Component Location



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Power Systems

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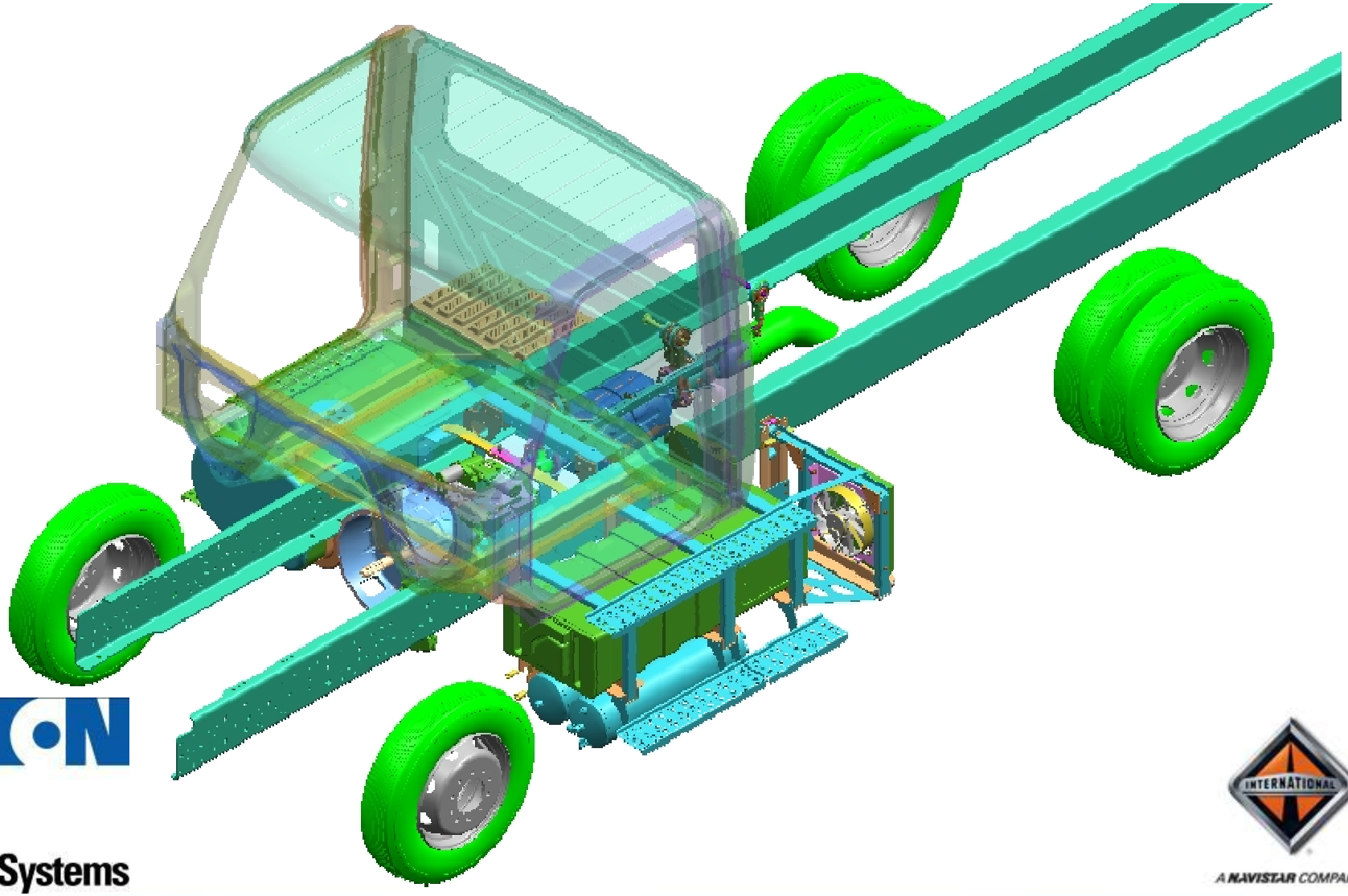
Hybrid System Component Location



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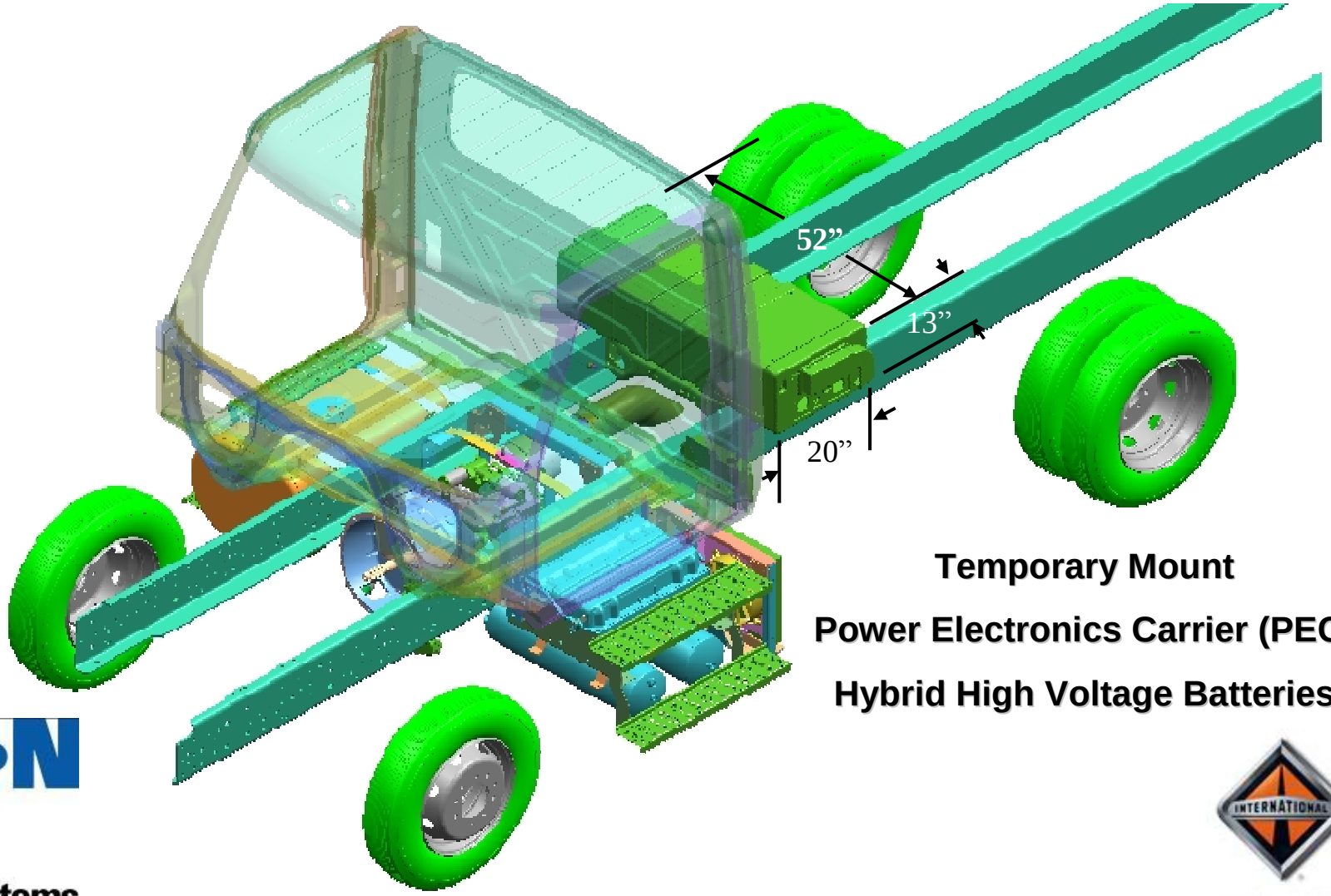
Hybrid System Component Location



Temporary Mount

Power Electronics Carrier (PEC)

Hybrid High Voltage Batteries

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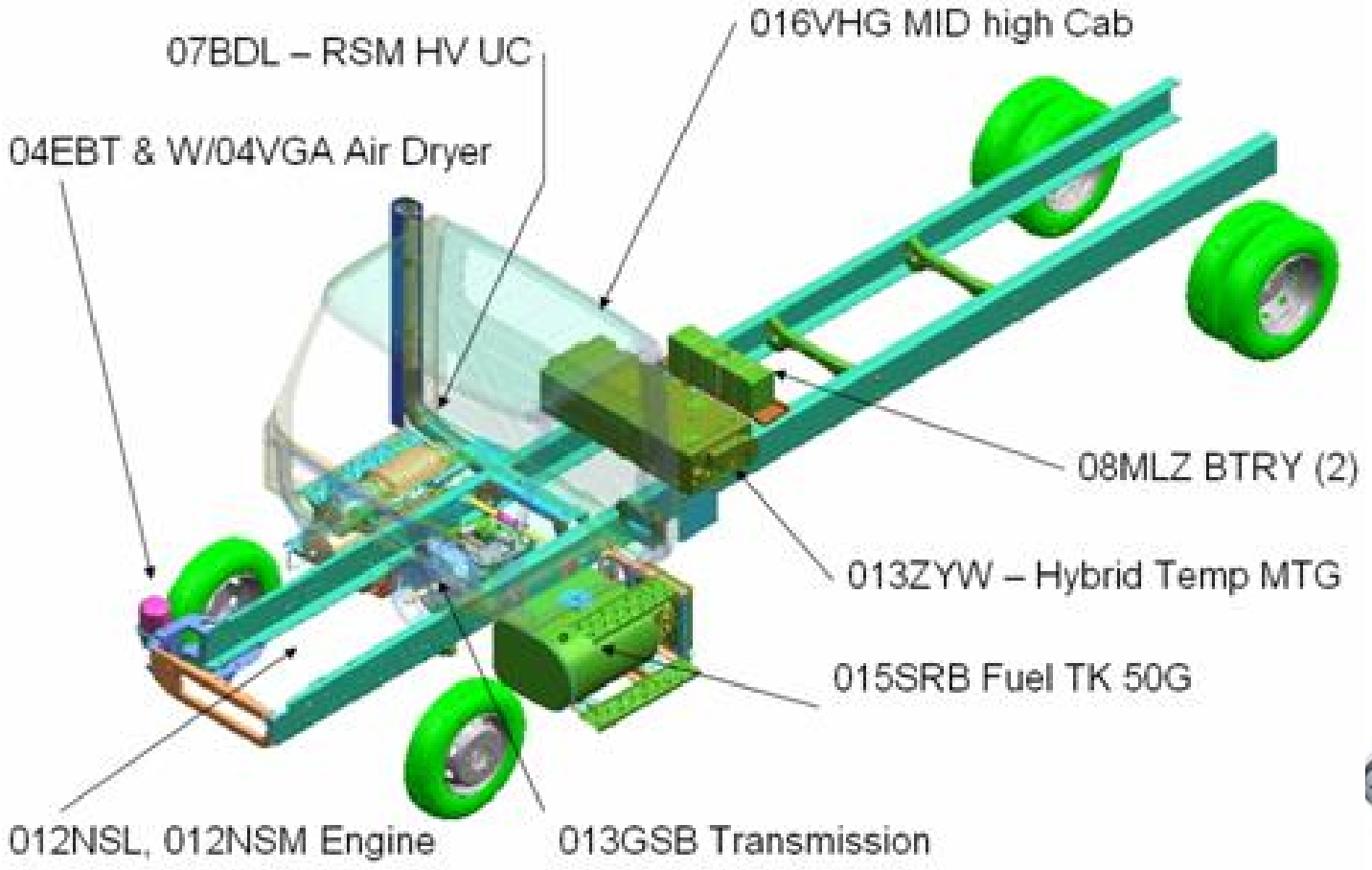
Chassis Packaging - Drop Frame

ISO View – STD Mid High Cab – Hybrid Beverage



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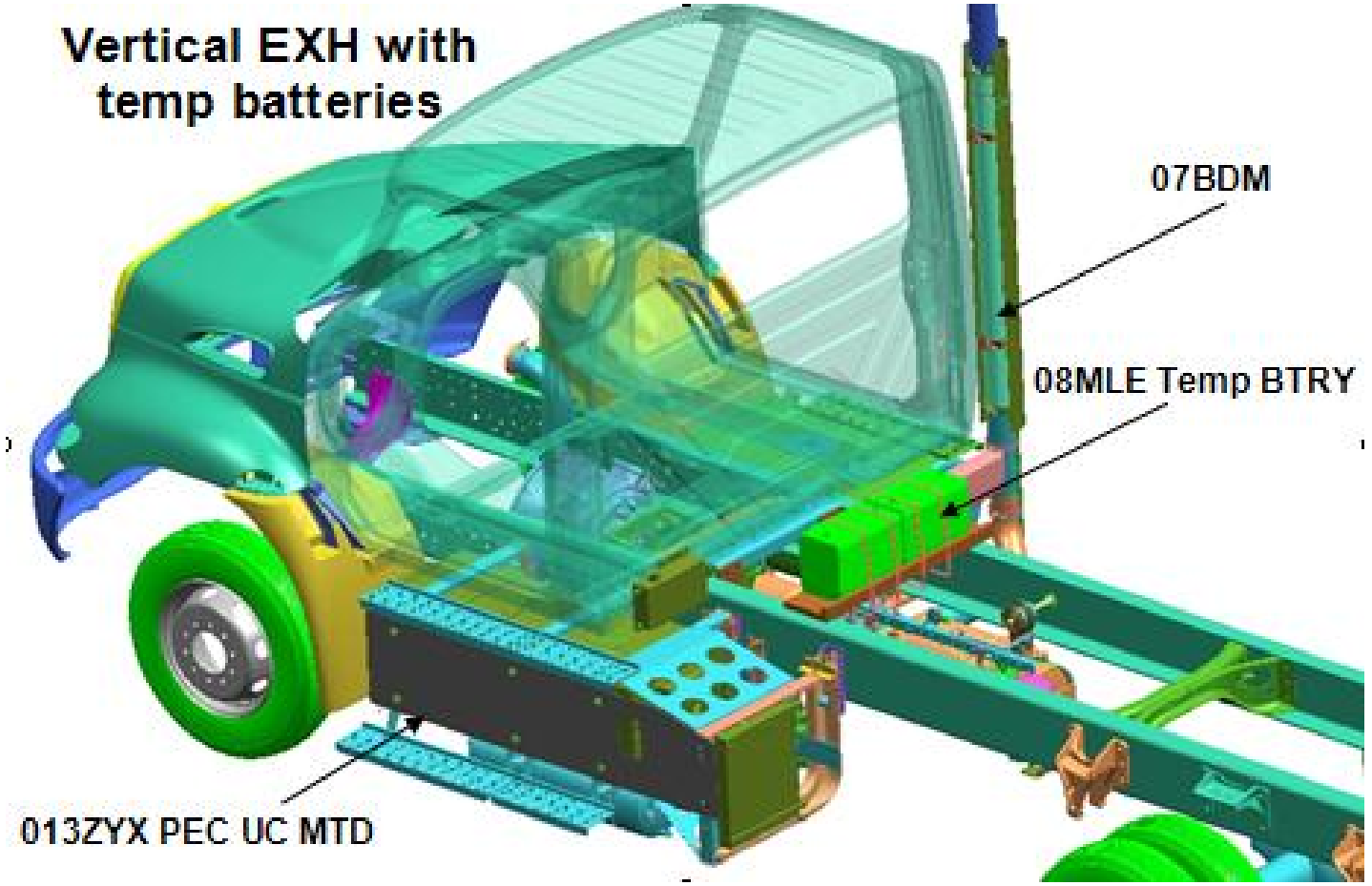
Chassis Packaging - Temporary Truck Batteries



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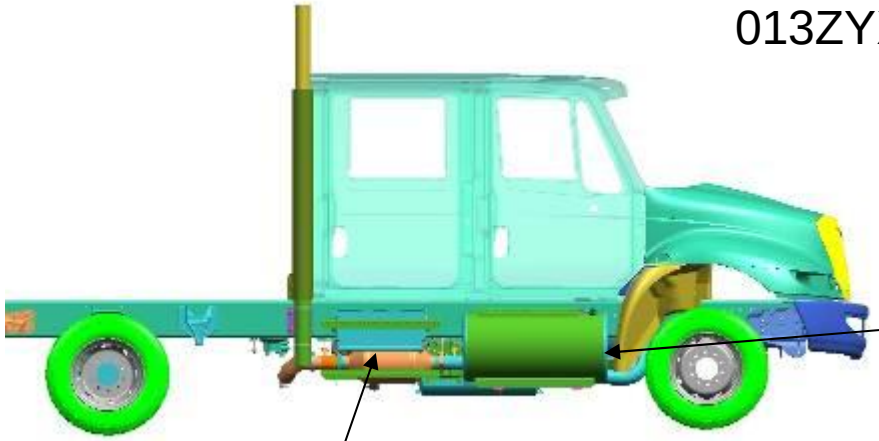
Chassis Packaging - Crew Cab

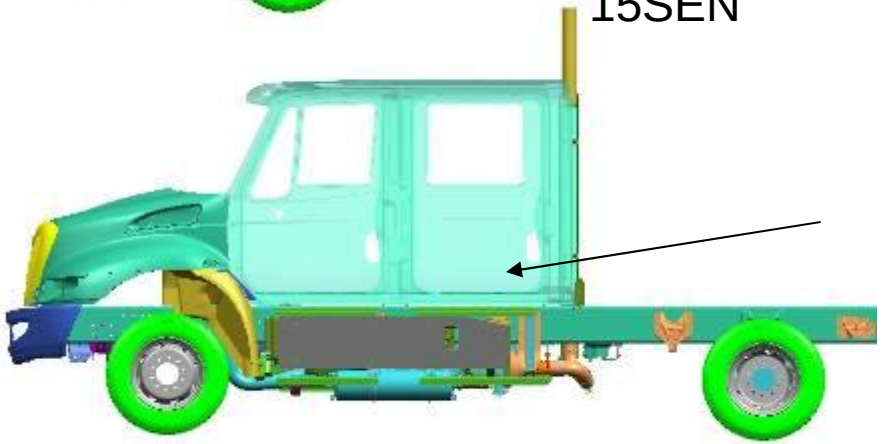
07BDM

013ZYX



15SCD
15SGK
15SGH
15SEN

508033
Battery Box



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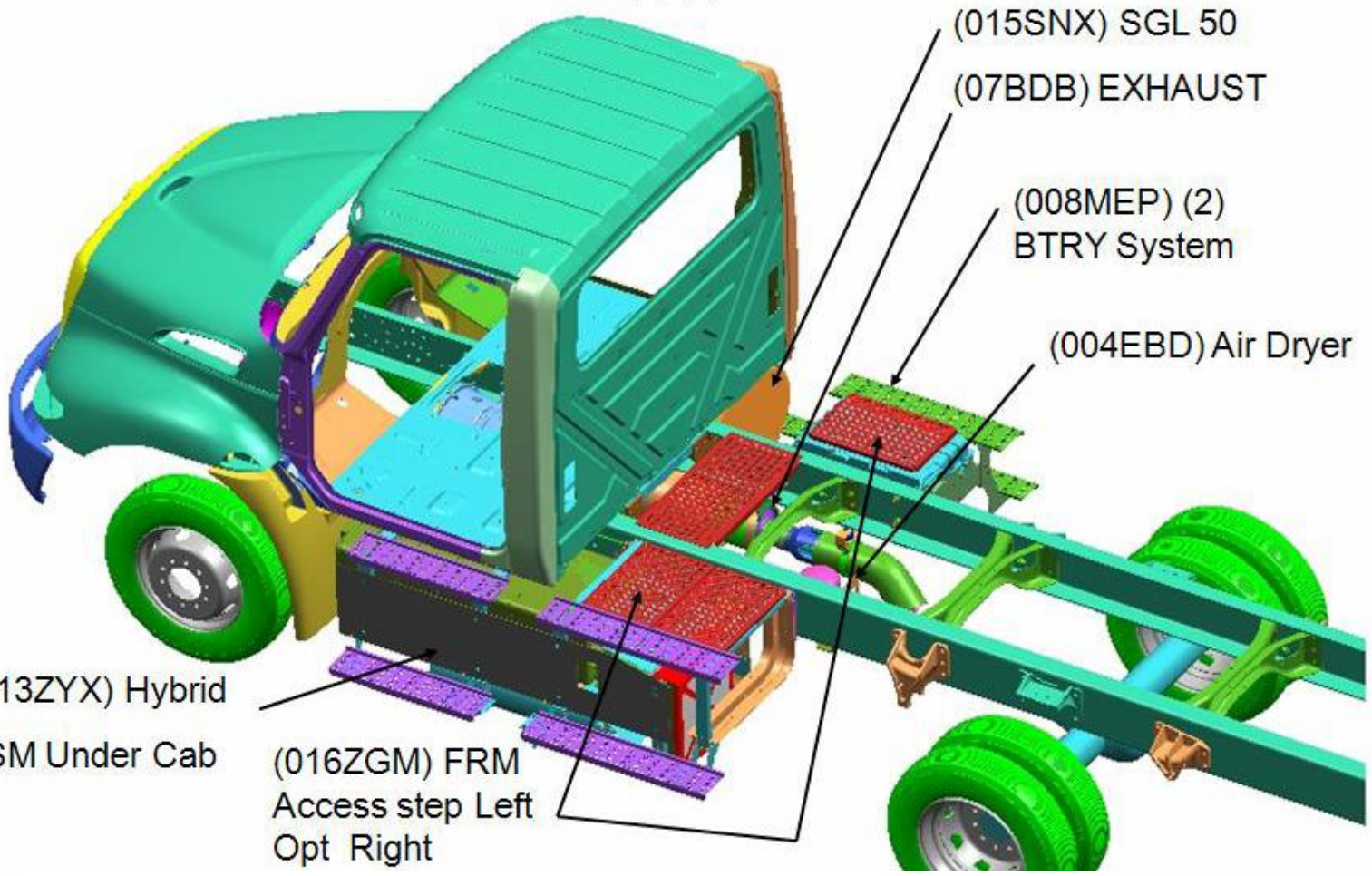
Chassis Packaging - Hybrid Tractor System

Rear LH ISO View – Hybrid Tractor – 3850 (152") WB



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Hybrid Power Systems

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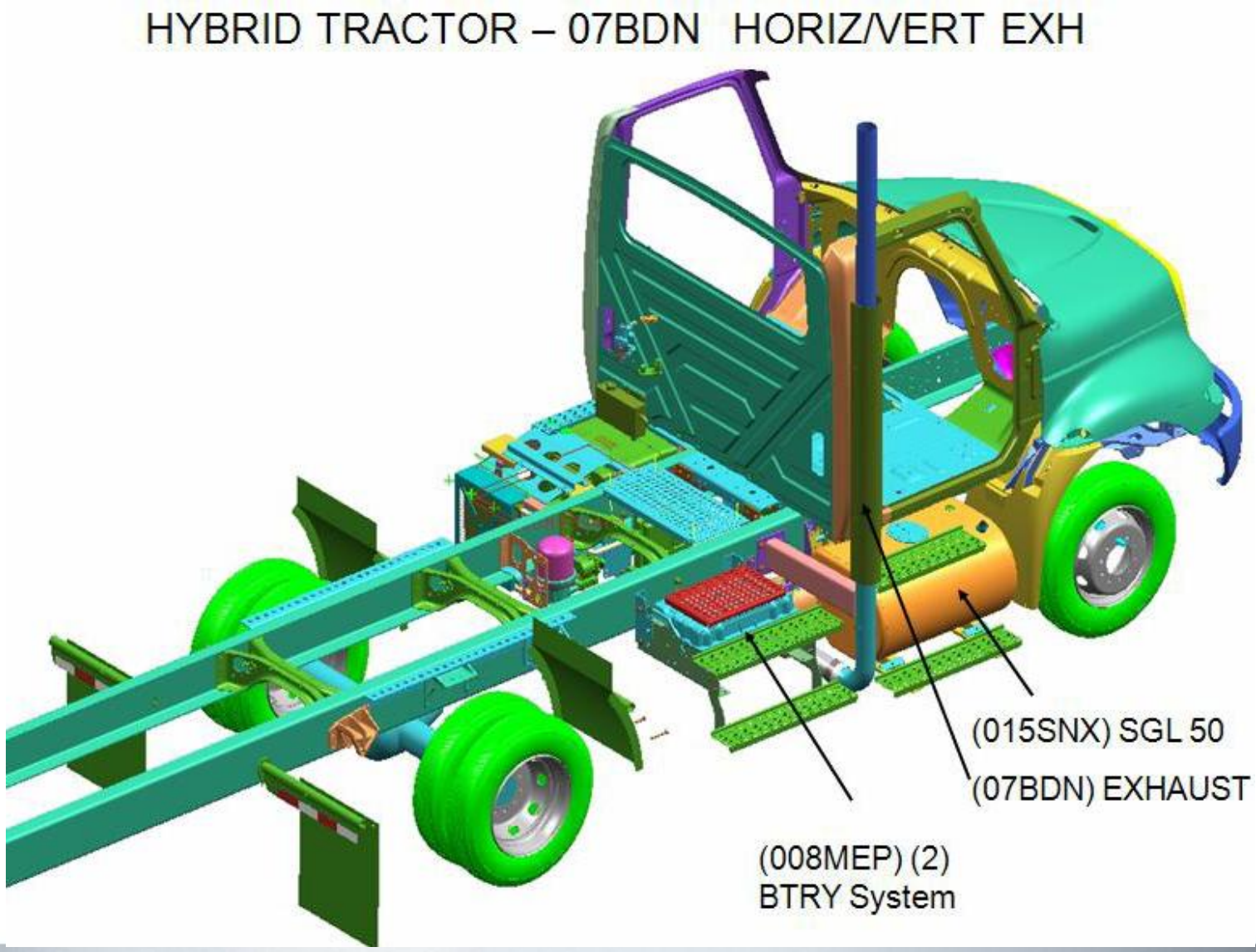
Chassis Packaging - Hybrid Tractor System



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Power Systems

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System Description & Operating Modes

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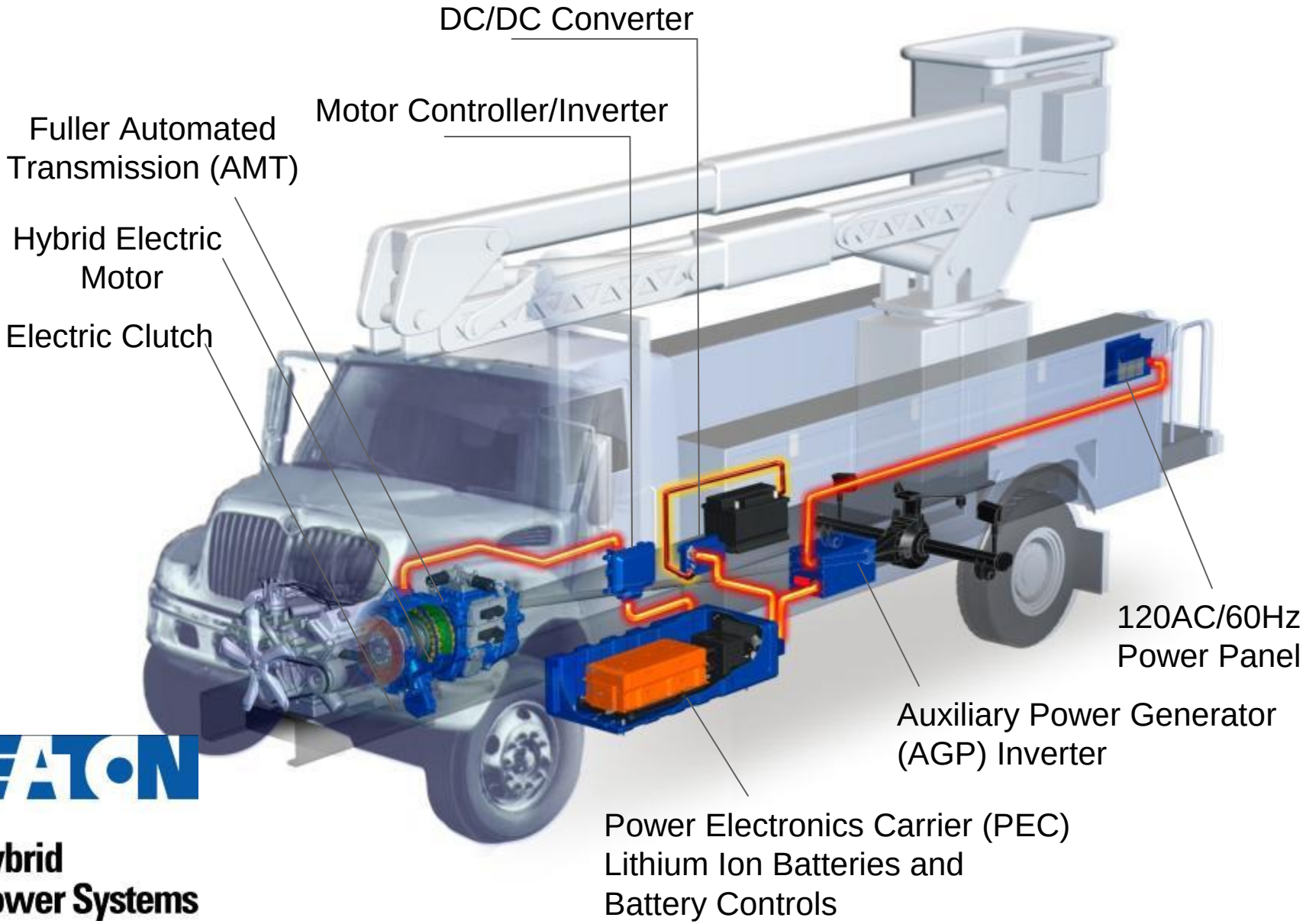
Hybrid System Diagram



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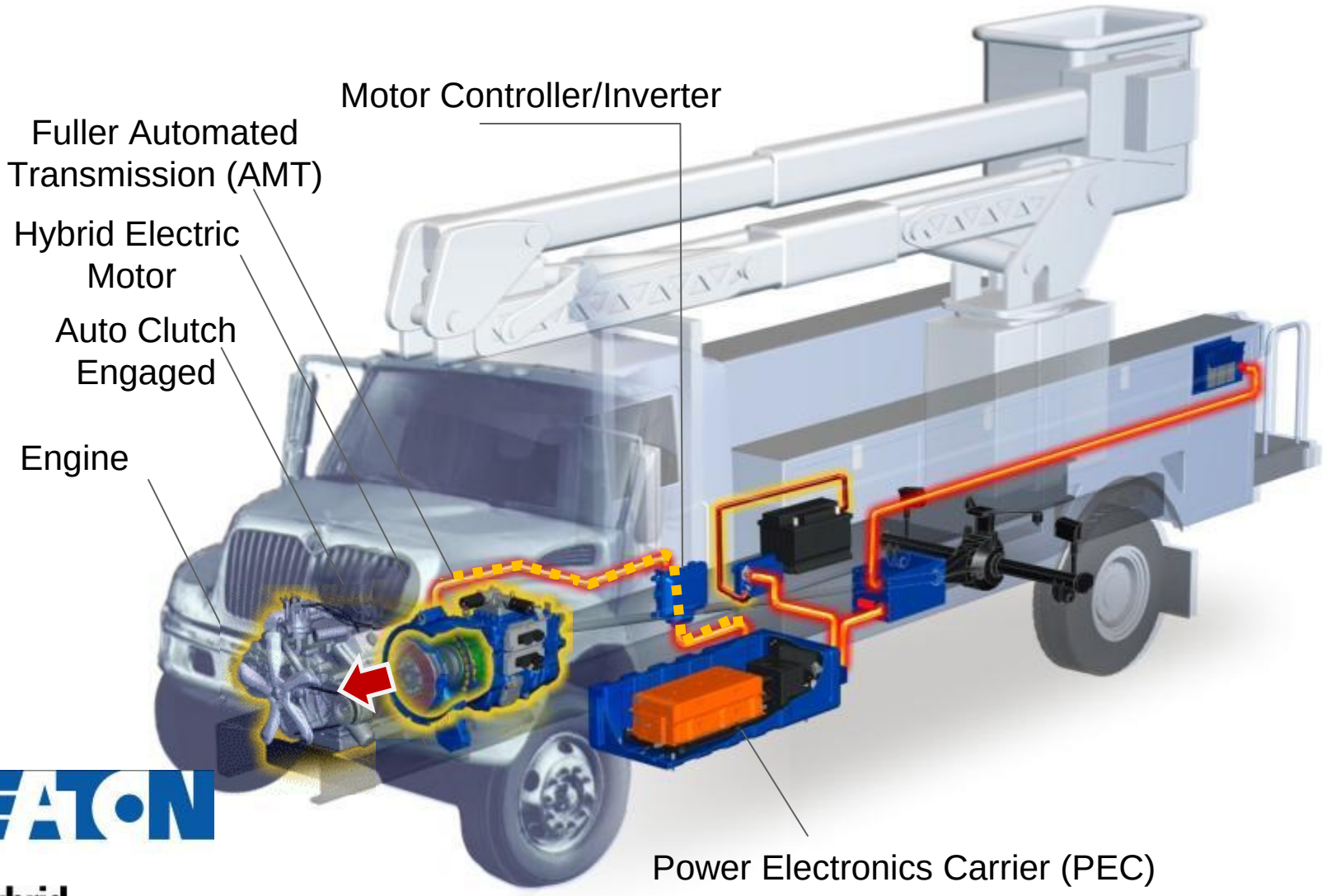
Hybrid Power Systems

Direct Hybrid – Engine Starting Mode



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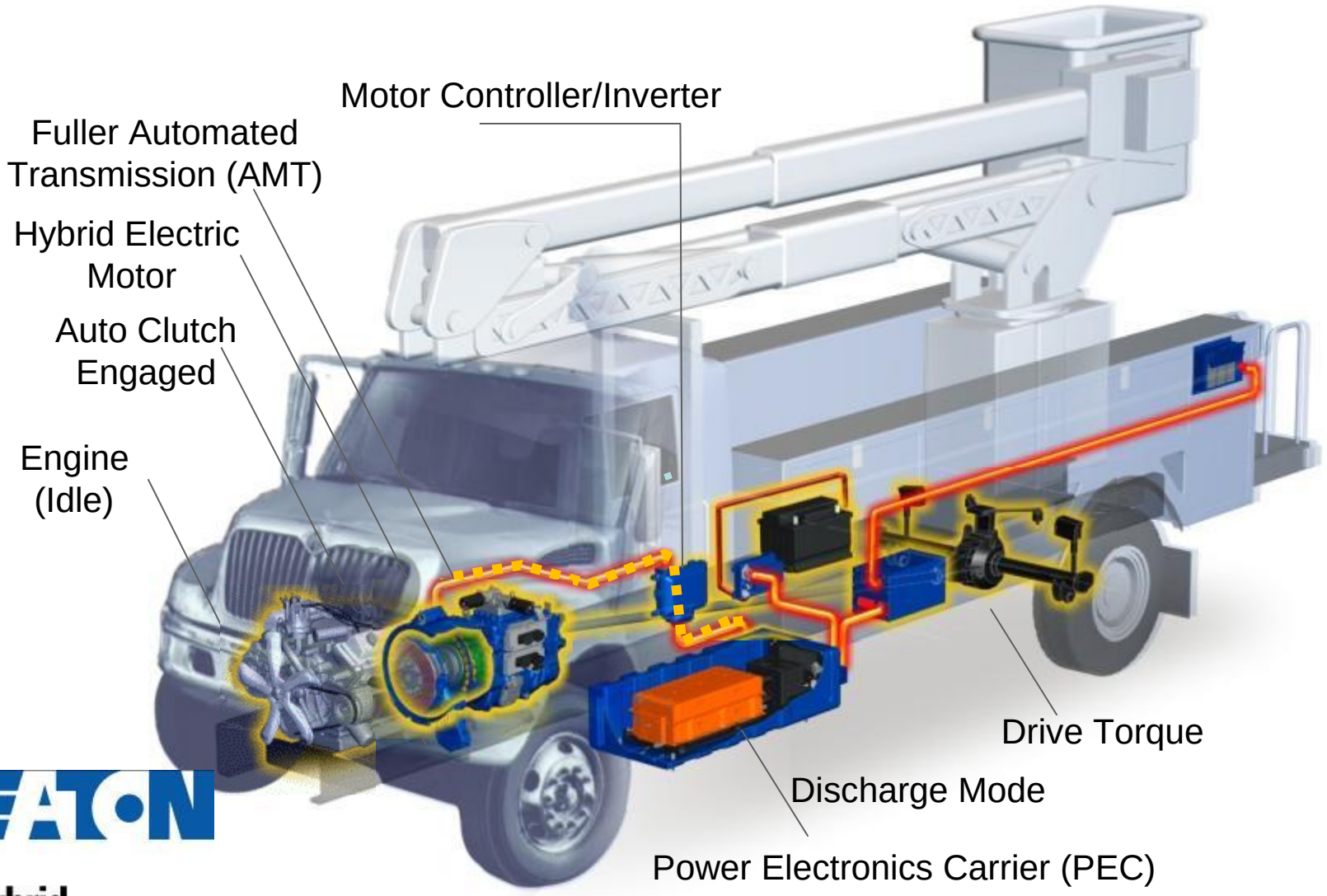
Direct Hybrid – Electric Only Mode



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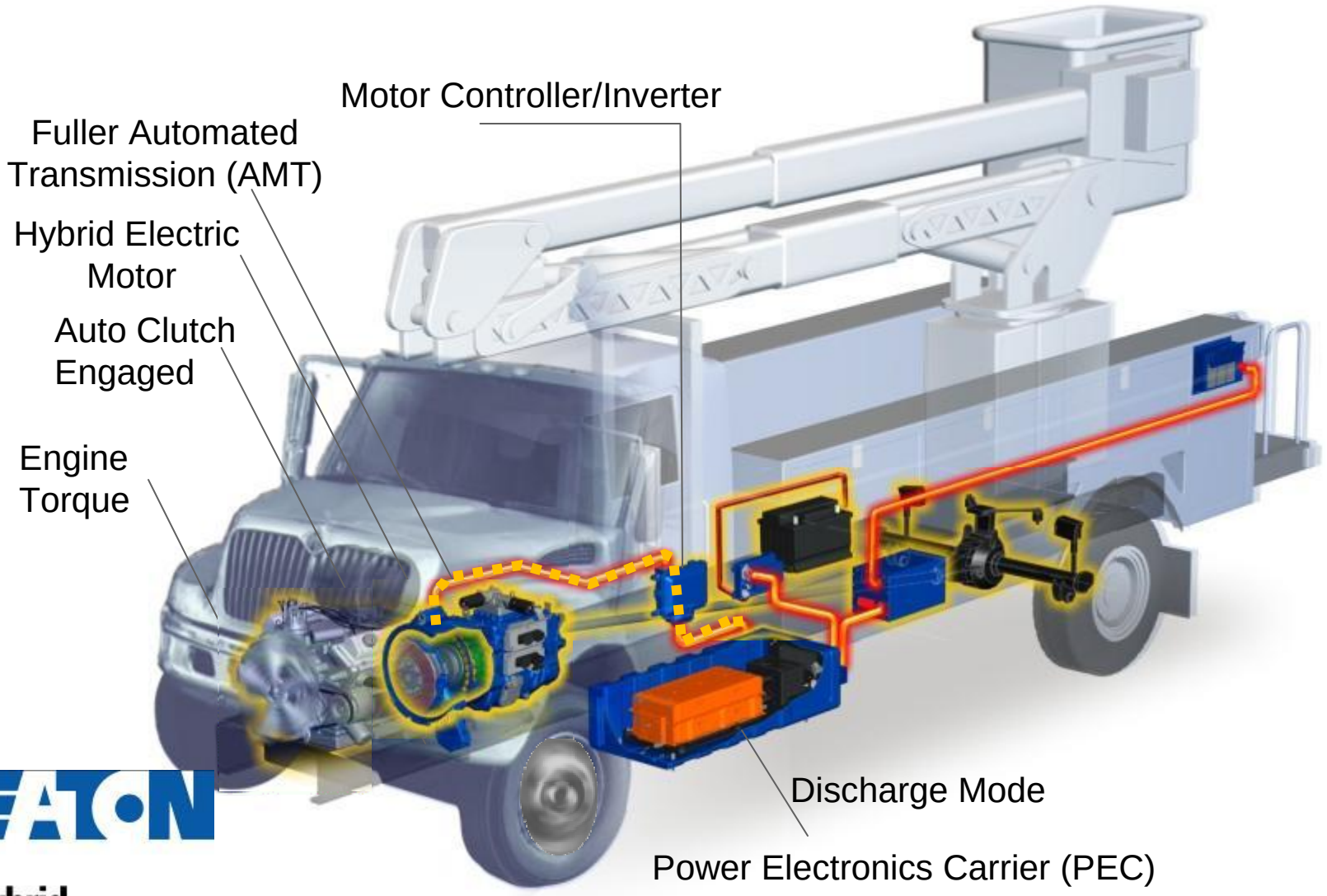
Direct Hybrid – Engine & Motor Drive Mode



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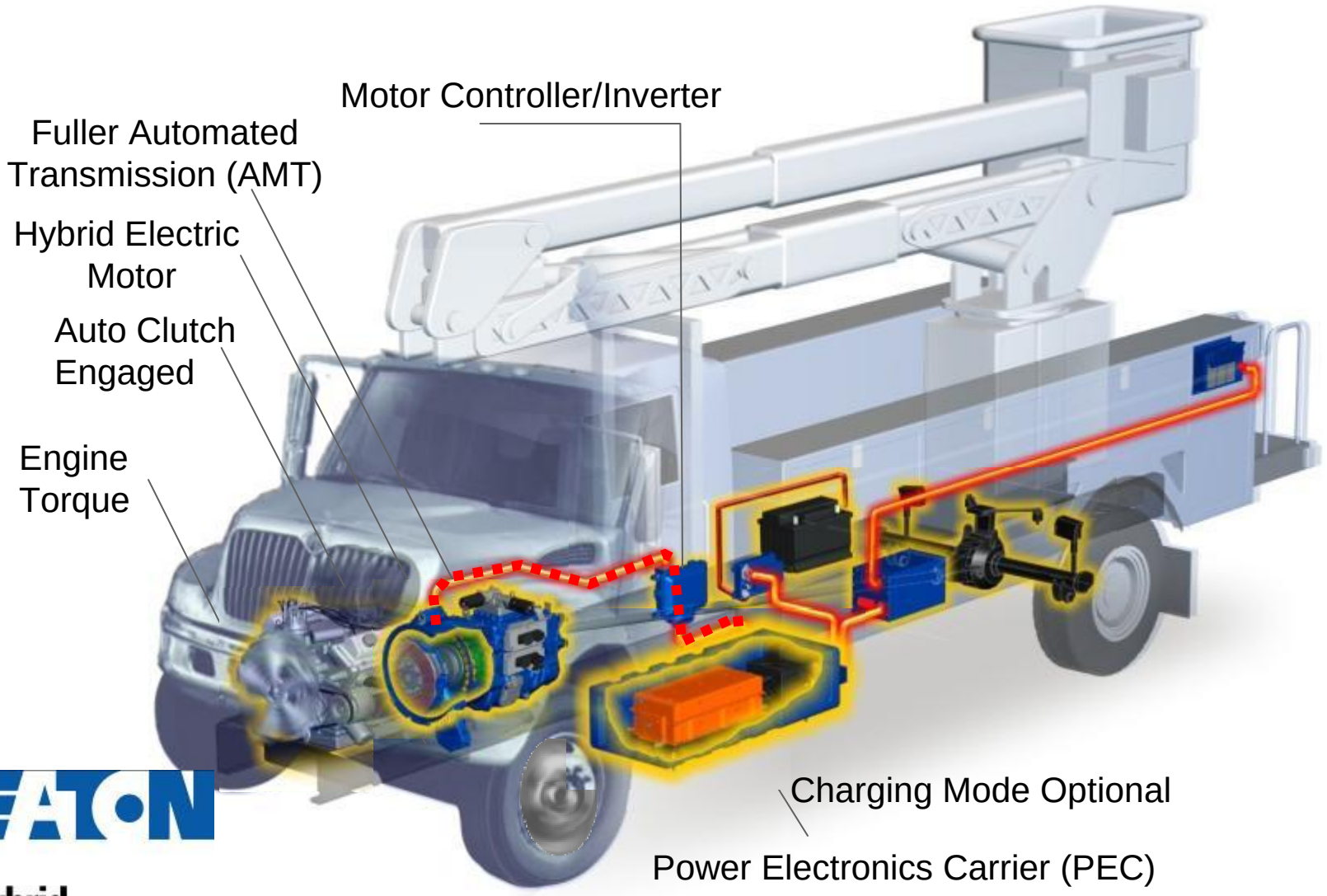
Direct Hybrid – Engine Only Mode



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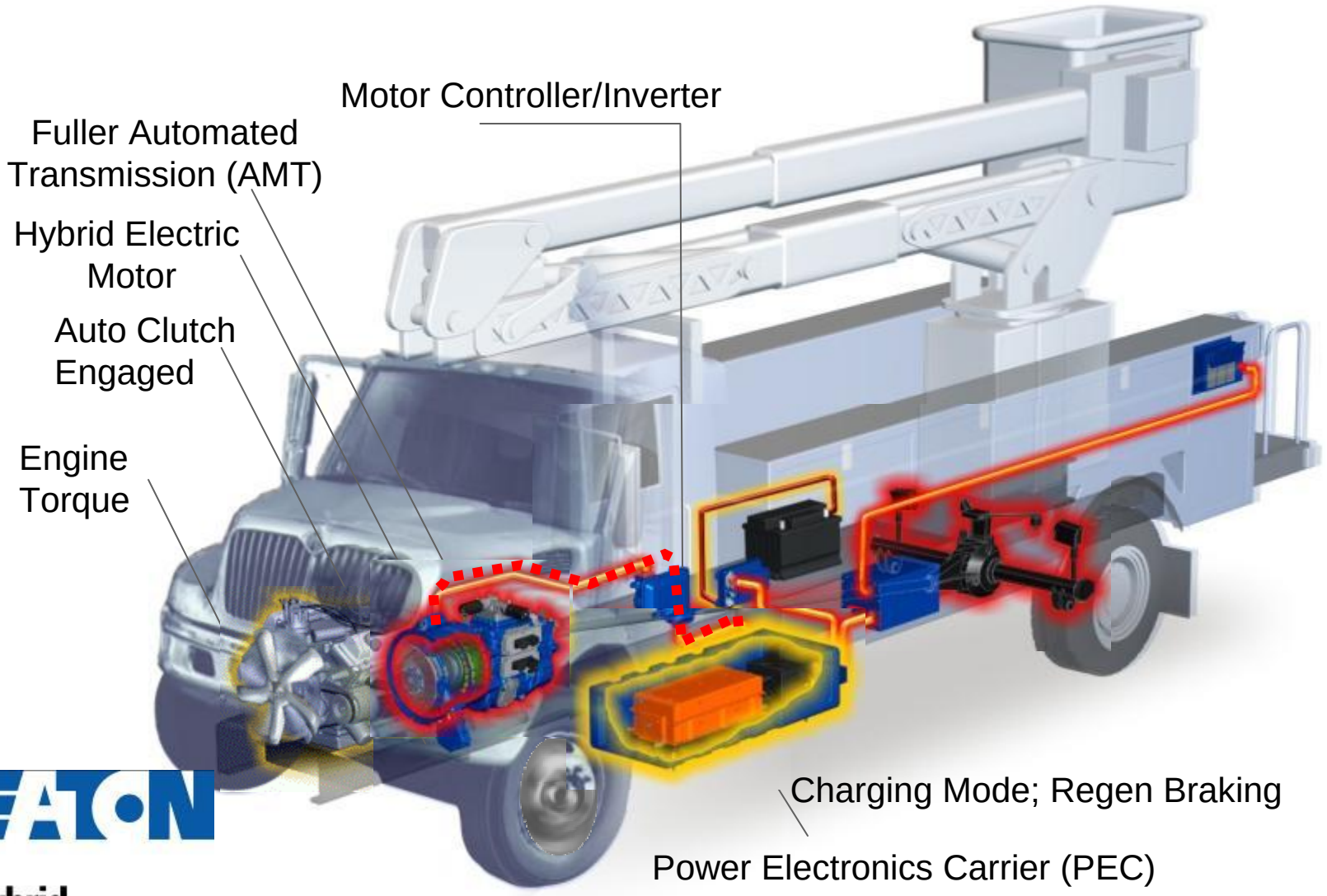
Direct Hybrid – Braking/Regeneration Mode



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Hybrid
Power Systems

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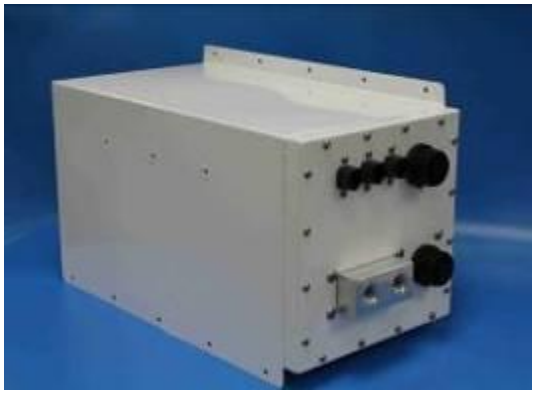
Newly Released

APG / APU

- **Drives AC loads from hybrid battery source**
  - 260-434V DC to 120V AC at 5 KW (6KW peak)
- **3 individually GFCI protected 120 volt A/C duplex outlets**
- 1 to 1½ hours 5KW operation on charged hybrid batteries (engine off)
- 6-8 Minute engine on to recharge hybrid batteries
- Advantage is engine off, while providing A/C power through hybrid batteries
- **Two part design enables flexible mounting**



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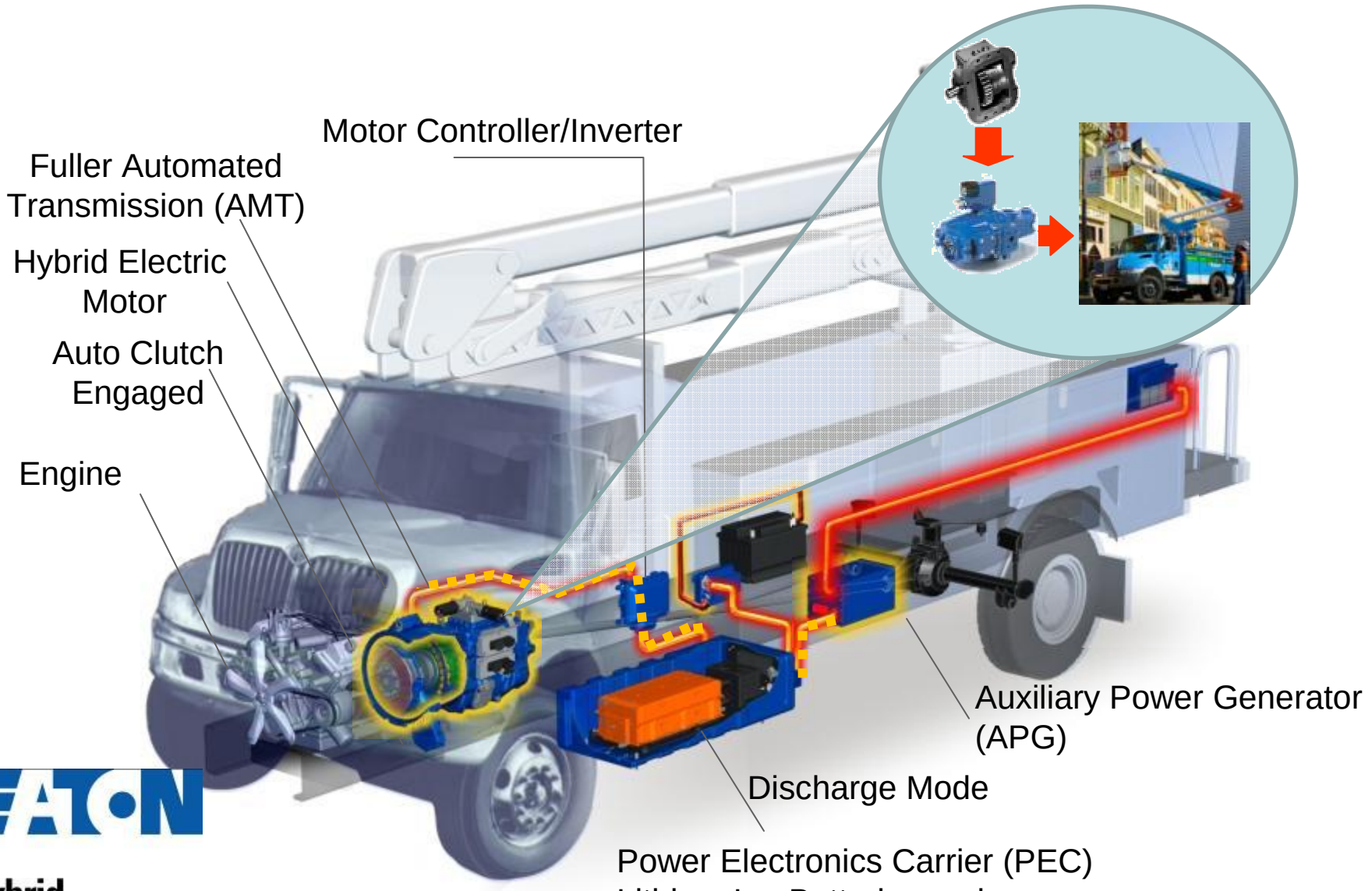
Direct Hybrid – Engine off ePTO & APG



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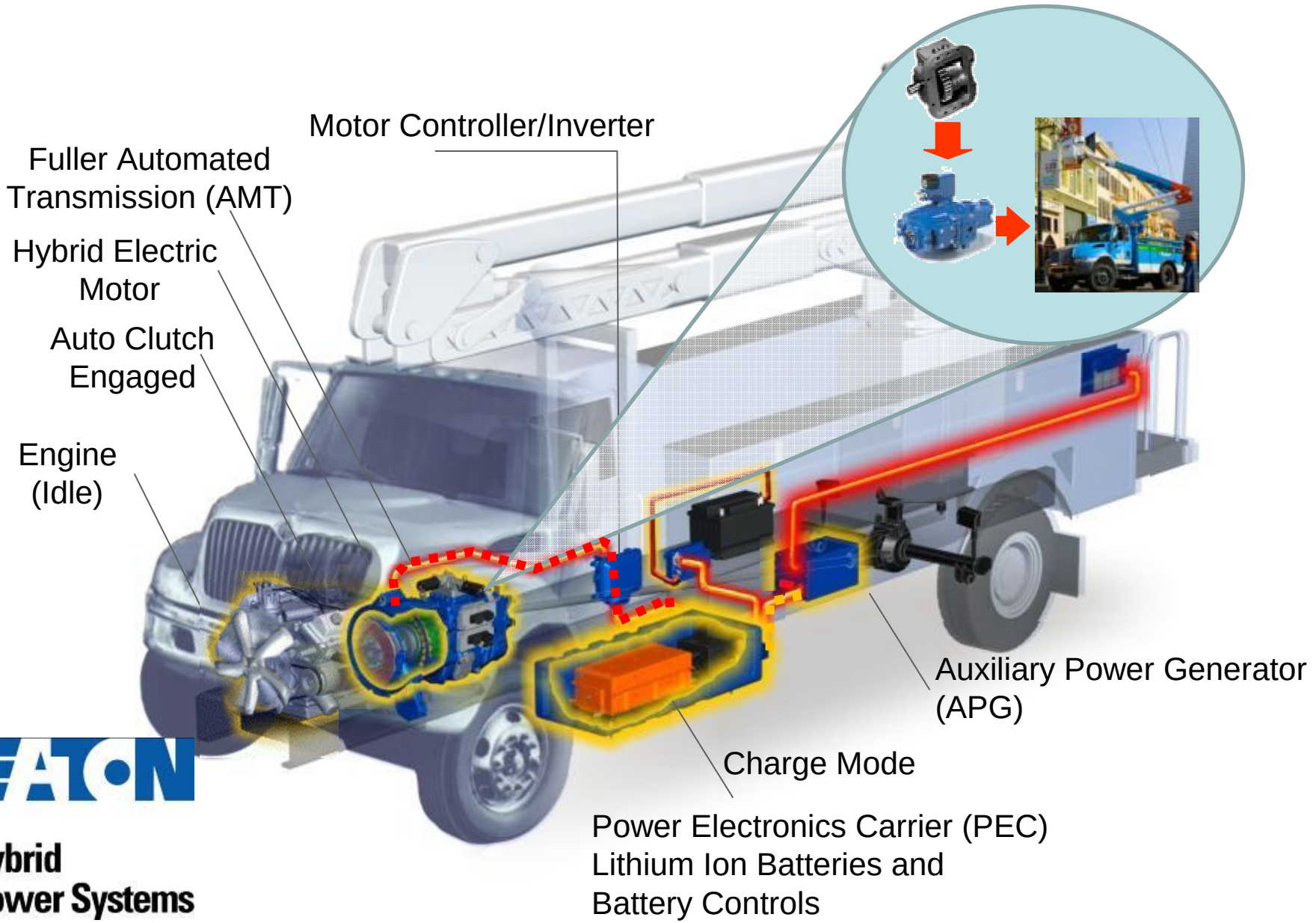
Direct Hybrid – Engine on ePTO & APG



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Hybrid
Power Systems

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Hybrid Launch

- **Completed test validation**
  - Beverage Box Van unit in service for more than 2 years
    - ***37%* improvement in fuel economy with *97%* uptime**
  - 24 HTUF units running for better than 3 years
- ***Positive results to date + 3.0 million miles***
  - Over 350 units built with 2007 emission engines
  - Additional orders in-house

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How Do You Identify A Hybrid?

- Vehicle displays “Hybrid” on the outside
- Dashboard shift label displays “Eaton Hybrid”
- Presence of bright orange high voltage cables

12 Regional Show Trucks

24 HTUF units

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How Do You Identify A Hybrid?

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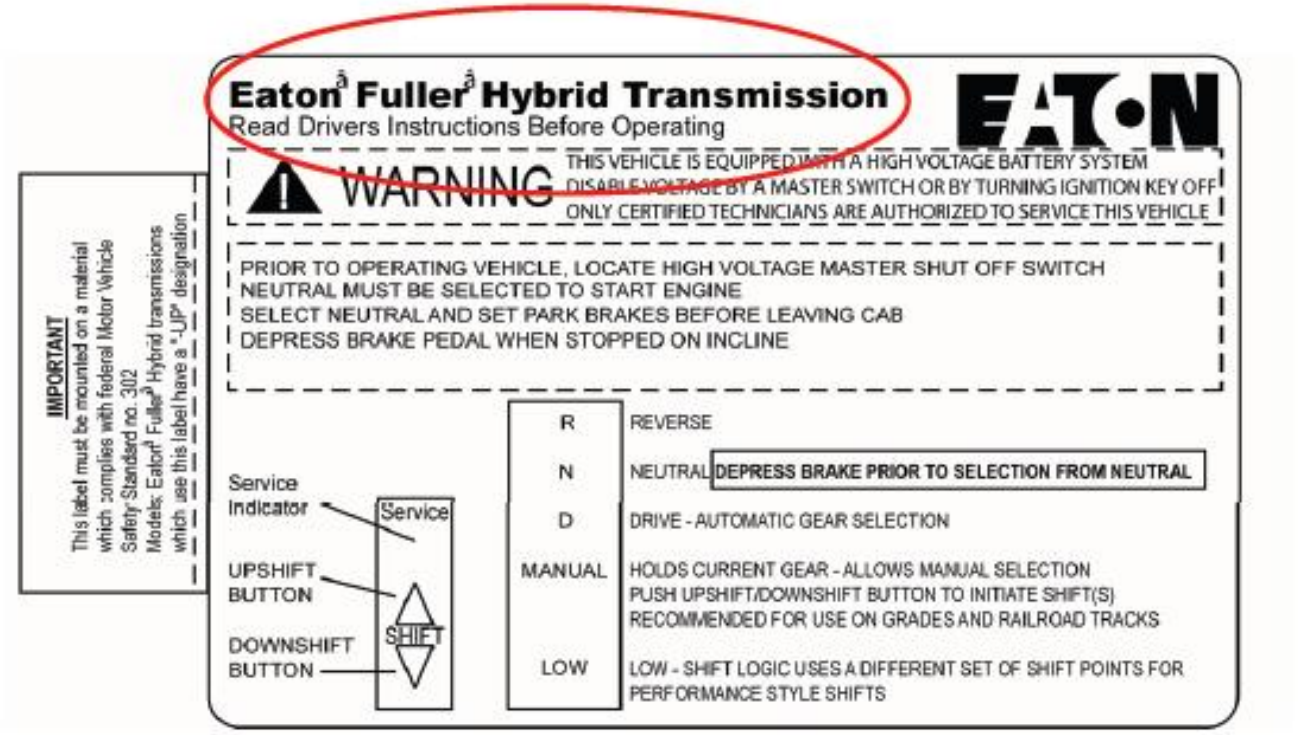
How Do You Identify A Hybrid?

Shift Label on “doghouse” inside cab



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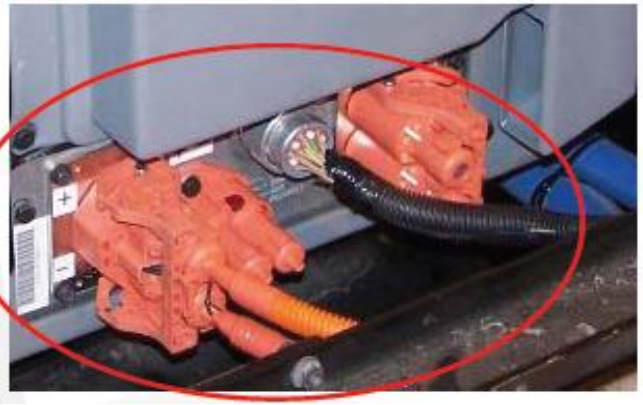
How Do You Identify A Hybrid?

Orange High Voltage Cables



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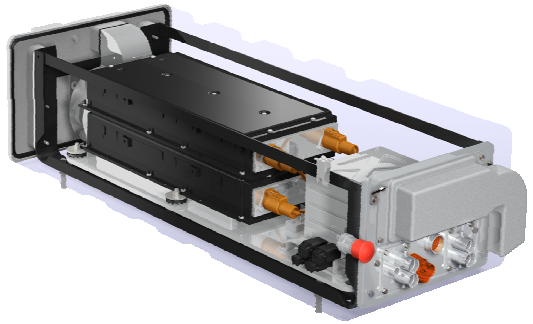
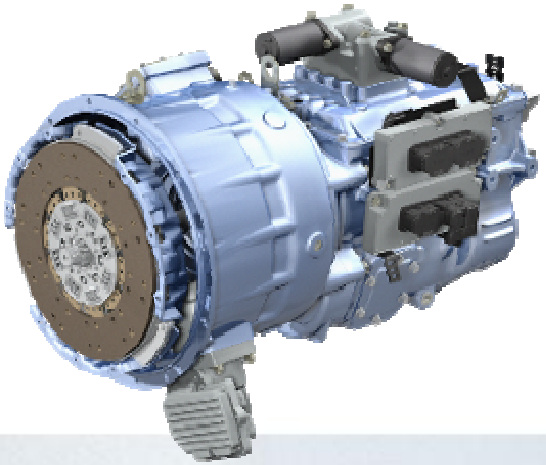
Hybrid Maintenance

- PEC requires air filter changes every 4-6 months



- Transmission oil - E500 synthetic lube, no change required for 500,000 miles

  Grease Zert through inspection cover for upper clutch cross shaft roller bearing



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Hybrid Power Systems

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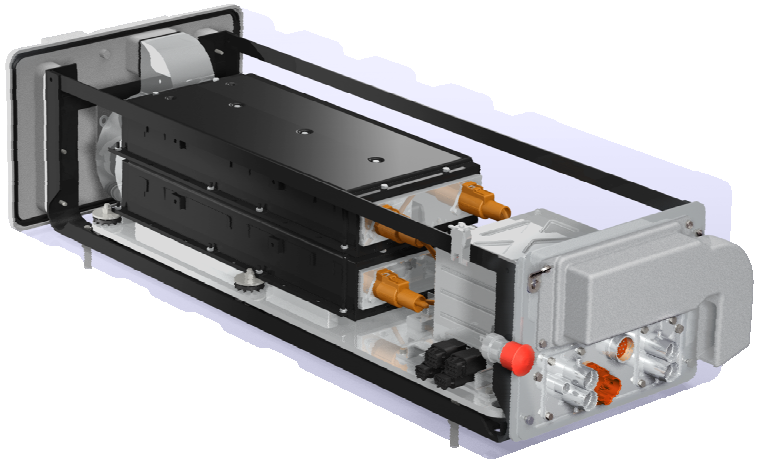
Battery Life Expectancy

- Current life projection 6-8 years
- Strongly dependant upon application, duty cycle
  - Continued focus on:
    - PEC Serviceability
    - Component exchange program
    - Reman program



Hybrid Power Systems

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Eaton Hybrid Warranty

- Standard warranty - 3 years / 150,000 miles
  - Includes base transmission and Eaton supplied Hybrid system*

  *Cooling portion of system International Truck & Engine supplied
- Extended warranty coverage additional 2 years & additional 50,000 miles

Vocation	Model	Torque	Standard Warranty	Additional Coverage Years / Miles (000)			
				Option #1 w/o PEC	Price	Option #2 w/ PEC	Price
Construction (Utility)	All	All	3/150	2/50	$3020 USD	2/50	$3870 USD
City Delivery				2/50	$2750 USD	2/50	$3515 USD

Hybrid Power Systems

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Legislative Activity

- **Federal**
  - **Energy Policy Act of 2005 for tax credits**

Vehicle weight	Max for 30%-39% FE Increase 20% of Incremental	Max for 40% -49% FE Increase 30% of Incremental	Max for ≥ 50% FE Increase 40% of Incremental
8,501 – 14,000 lb	$1,500	$2,250	$3,000
14,001 – 26,000 lb	$3,000	$4,500	$6,000
≥ 26,001 lb	$6,000	$9,000	$12,000

- **Where can you find funding support?**
  - **Fleet should be able to look up list of approved vehicles on IRS or DOE Website.**
  - **http://www.irs.gov/newsroom/article/0,,id=157557,00.html**

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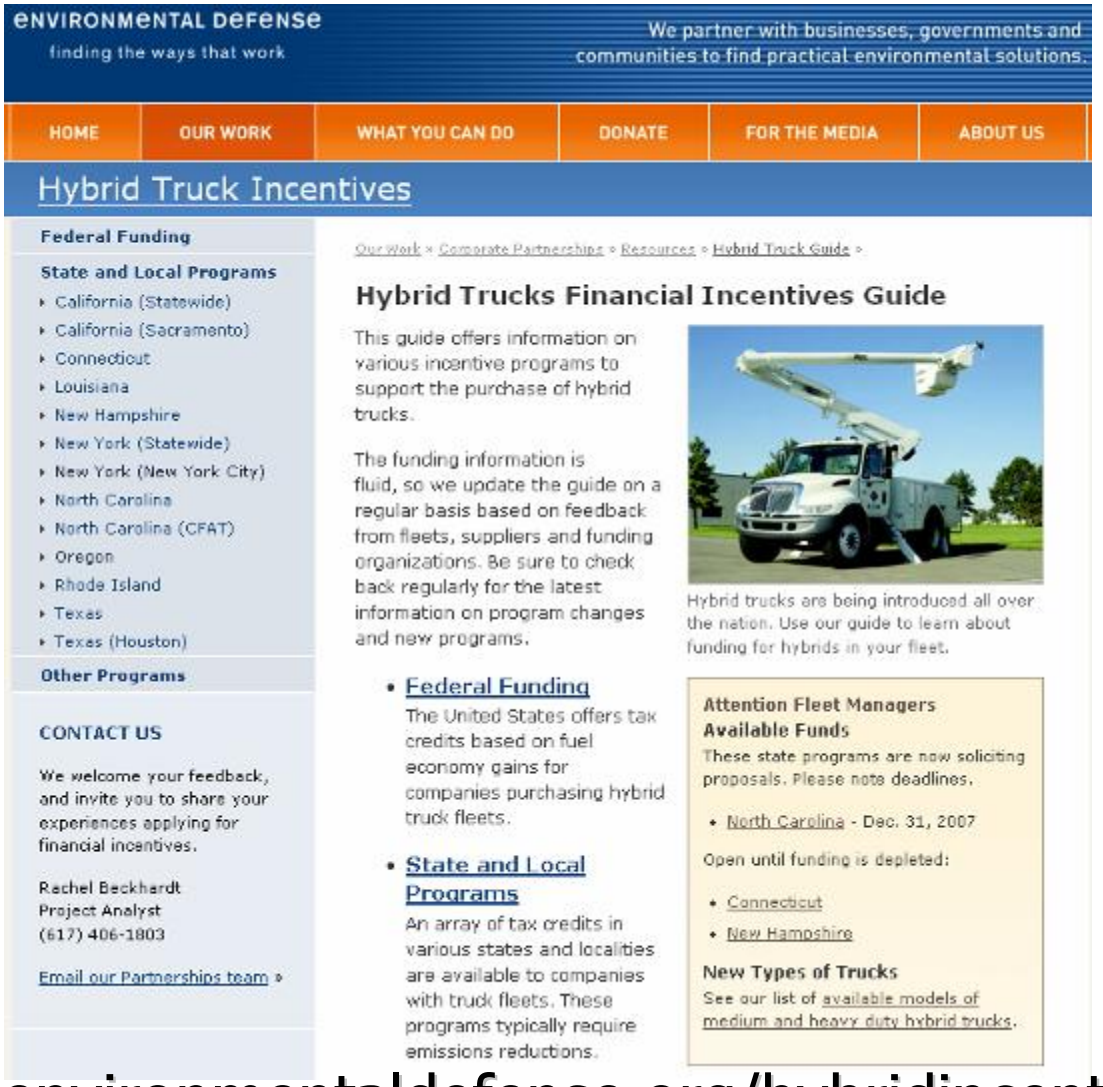
Environmental Defense Hybrid Truck Incentives Guide



www.environmentaldefense.org/hybridincentives

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HYBRID TECHNOLOGY

Business Case for Hybrids

- What is the **incremental** cost for a hybrid today?
  - E-PTO System (Utility)

Non-hybrid E-PTO unit

Hybrid E-PTO unit

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Pricing & Incentive Impact

Category	2008 Calendar Year Hybrid	2008 Calendar Year Non-Hybrid	Differential
Base Chassis	**$55,000**	**$55,000**	**$0**
HEV System			
Allison 3000			
MaxxForce DT & 225 HP			
Federal Tax Credit			
State Incentives (Up to 80% HEV Cost)			
HEV Cost			
Annual fuel Savings			
Payback			

Pricing & Incentive Impact

Category	2008 Calendar Year Hybrid	2008 Calendar Year Non-Hybrid	Differential
Base Chassis	**$55,000**	**$55,000**	**$0**
HEV System	**$53,600**	$0	**$53,600**
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Pricing & Incentive Impact

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Base Chassis	**$55,000**	**$55,000**	**$0**
HEV System	**$53,600**	$0	**$53,600**
Allison 3000	$0	$5,000	**$48,600**
MaxxForce DT & 225 HP			
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HEV System	**$53,600**	$0	**$53,600**
Allison 3000	$0	$5,000	**$48,600**
MaxxForce DT & 255 HP	$0	$1,000	**$47,600**
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Federal Tax Credit	**($12,000)**	$0	**$35,600**
State Incentives (Up to 80% HEV Cost)			
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Federal Tax Credit	**($12,000)**	$0	**$35,600**
State Incentives (Up to 80% HEV Cost)	**($33,280)**	$0	**$2,320**
HEV Cost			
Annual fuel Savings			
Payback			

Pricing & Incentive Impact

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HEV Cost		Base Line	**$2,320**
Annual fuel Savings			
Payback			

Pricing & Incentive Impact

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State Incentives (Up to 80% HEV Cost)	**($33,280)**	$0	**$2,320**
HEV Cost		Base Line	**$2,320**
Annual fuel Savings	**($4,500)** Average 50 % Fuel Savings		**($2,180)**
Payback		**Immediate**	

HYBRID TECHNOLOGY

Business Case For Hybrid?

- Dependent On Price of Fuel
- Dependent On Green House Gas Legislation
- Dependent On Body Application

Average $5.50 Diesel Over Next 8 years

- Base System @ 8 Years = $26,400 to $39,600
- e-PTO System (light) @ 8 Years = $44,000 – $66,000
- e-PTO System (heavy) @ 8 Years = $52,800 - $83,600
- How Are You Looking At Your Payback?
  - Grants & Tax Credits Still Critical!

It's The Right Thing To Do!

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HYBRID TECHNOLOGY

Top Ten Reasons to Choose

DURAStar HYBRID

1. Reduces Fuel Consumption
2. Reduces Emissions and Green House Gases
3. Assembly Line Production of HEV System
4. Over 3 years of in-service testing of system across North America
5. Complete HEV vehicle system warranty from one source
6. Improved Corporate "Green" Social image
7. Assistance to body builders to integrate and advantage hybrid system
8. Enhance vehicle performance and productivity
9. Fully integrated engine, transmission and vehicle electronics
10. International dealer service network support

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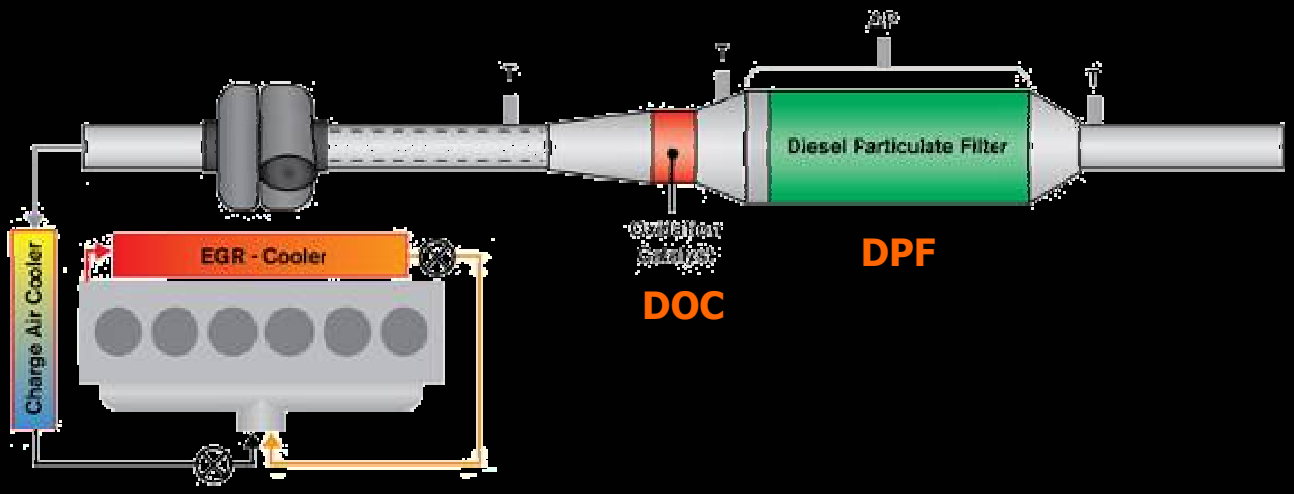
2010 Emissions - Navistar

Navistar Engines



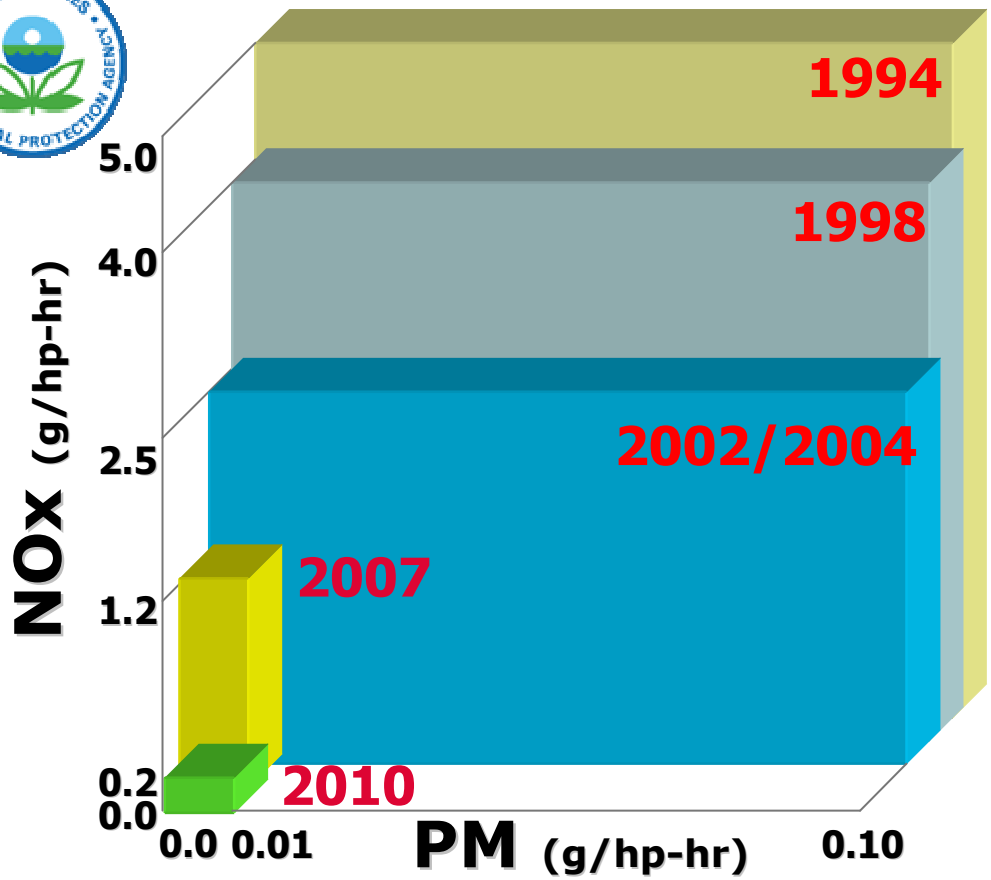
The Regulatory Landscape

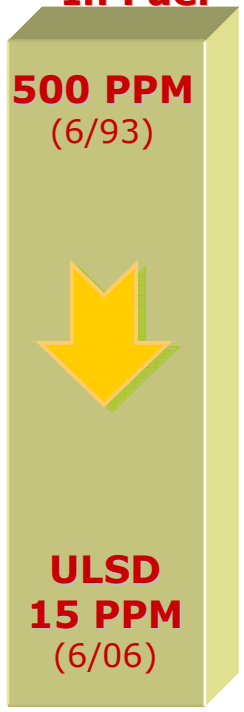
- Diesel Exhaust Emissions Regulations limit:
  - Oxides of Nitrogen (NOx)
  - Particulate Matter (Hydrocarbons HC, Soot)
  - Once in the atmosphere:
    - NOx results in ground level ozone formation
  - Particulates result in smog.

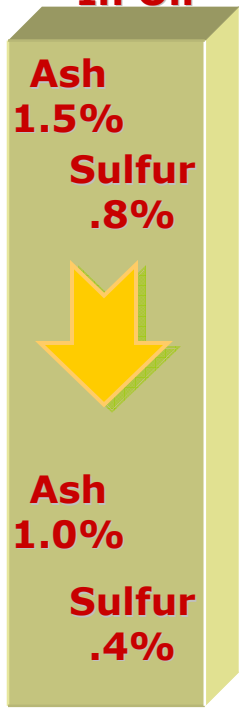
- US Emissions Regulations per Environmental Protection Agency

U.S. EPA Emissions Standards

Heavy-duty NOx + HC and PM Exhaust Emissions

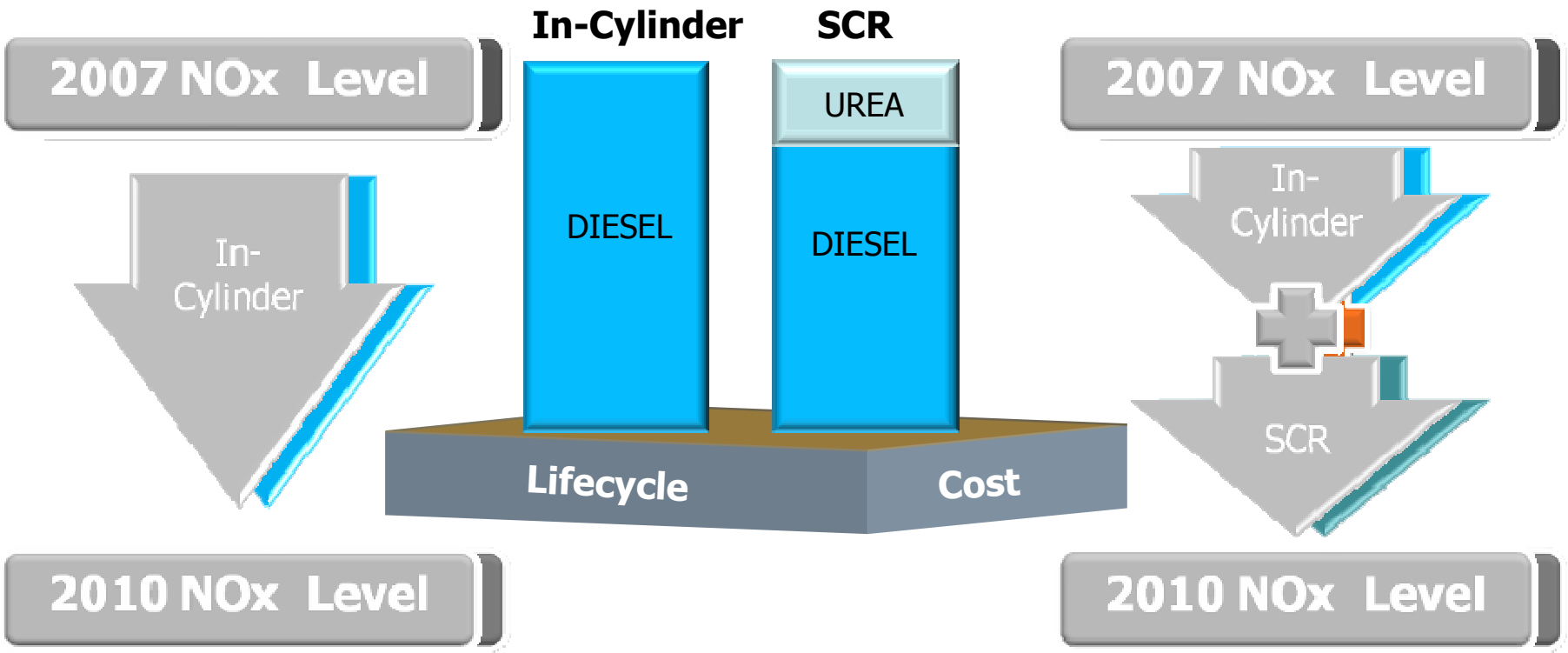






Important Point to note: 2007 Diesel emissions really does not impact green house gases or CO2 . The reduction is in NOx and PM. In order to reduce CO2, the only way it can be done in any magnitude is to not burn the fuel.

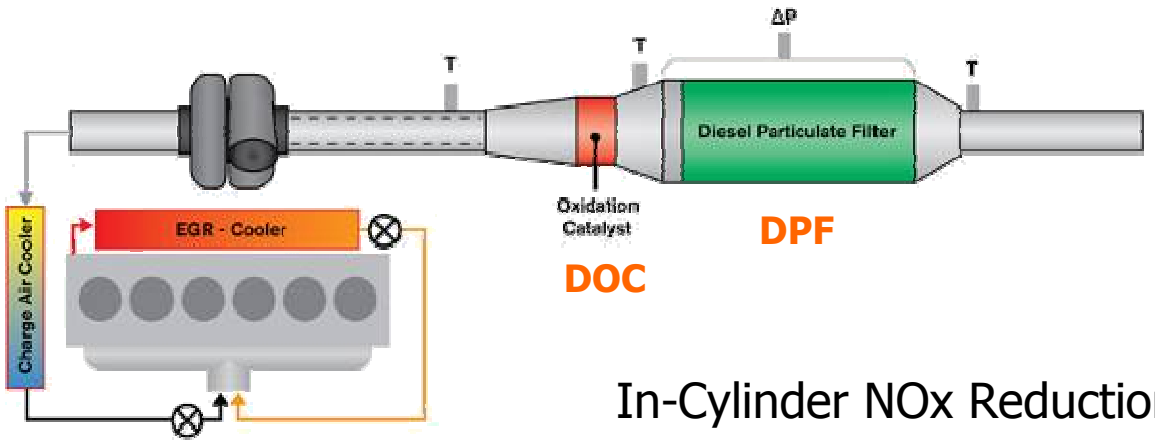
Emissions Strategies



In-Cylinder NOx Reduction

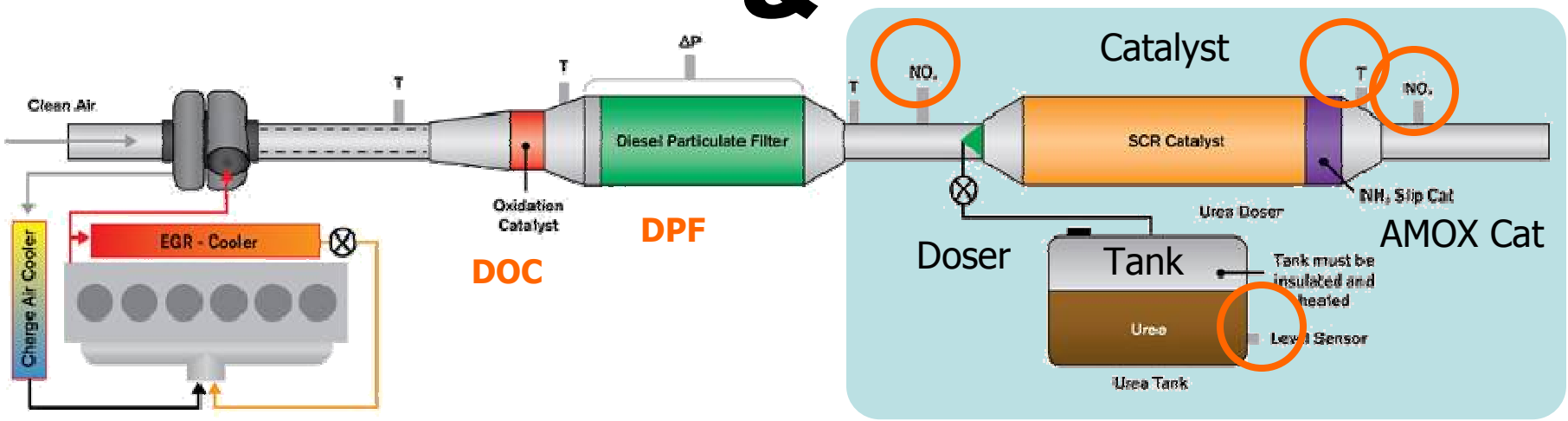
AFTERTREATMENT
EGR + SCR

Typical System Setups



In-Cylinder NOx Reduction system setup

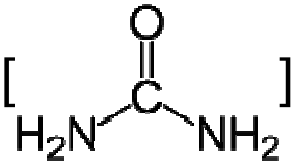
&



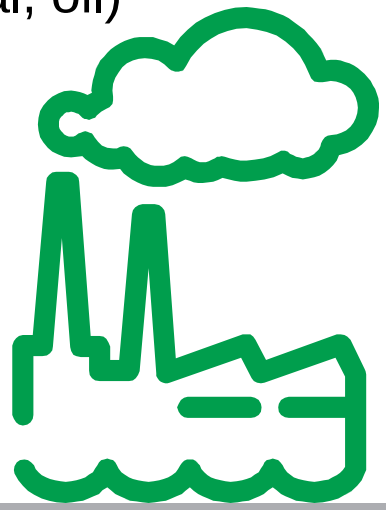
EGR + SCR After-treatment system setup

Selective Catalytic Reduction

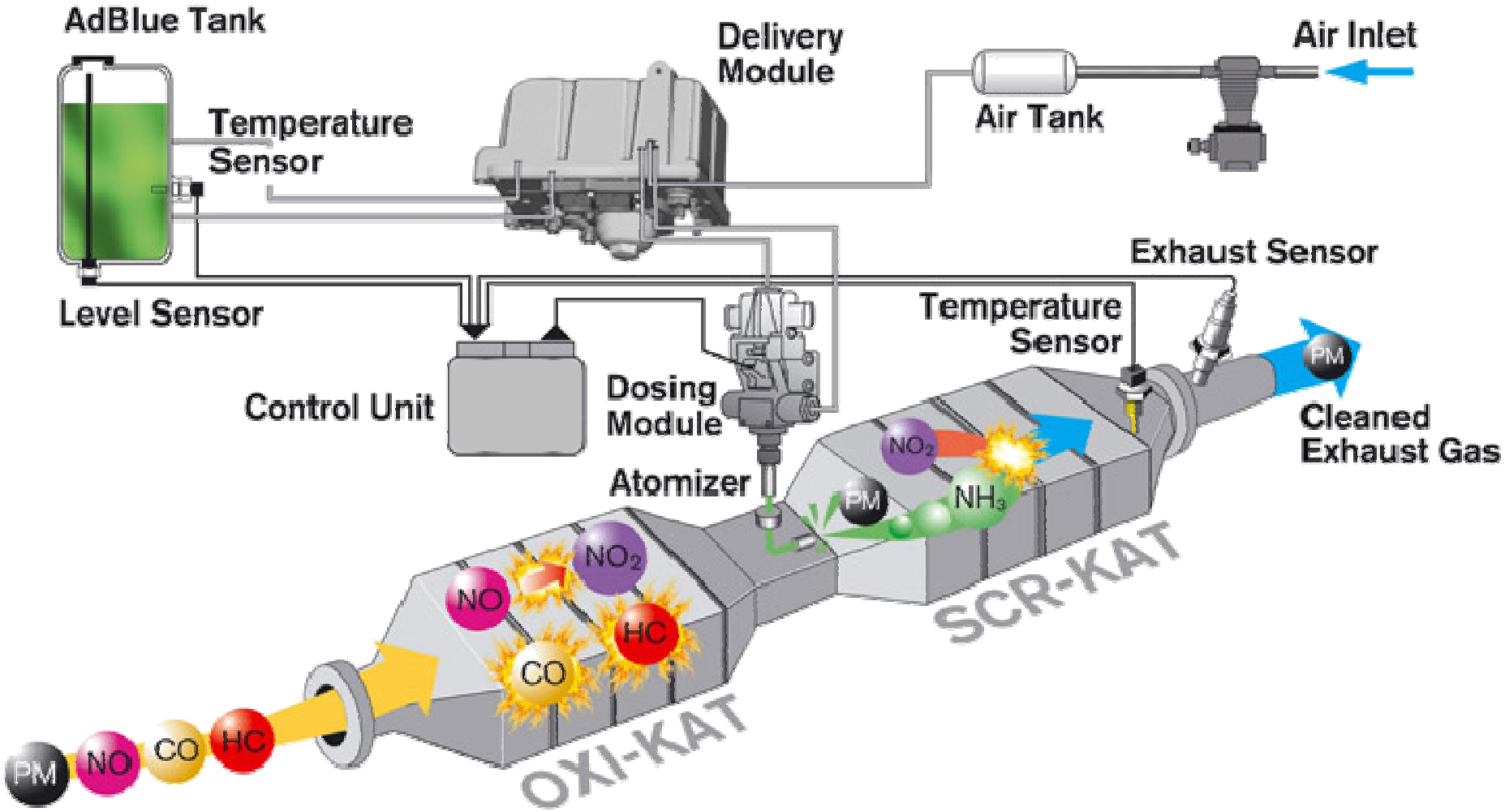
$$\text{Ammonia} + NOx \longrightarrow N_2 + H_20$$

- Urea [] used as a carrier of Ammonia (NH_3)

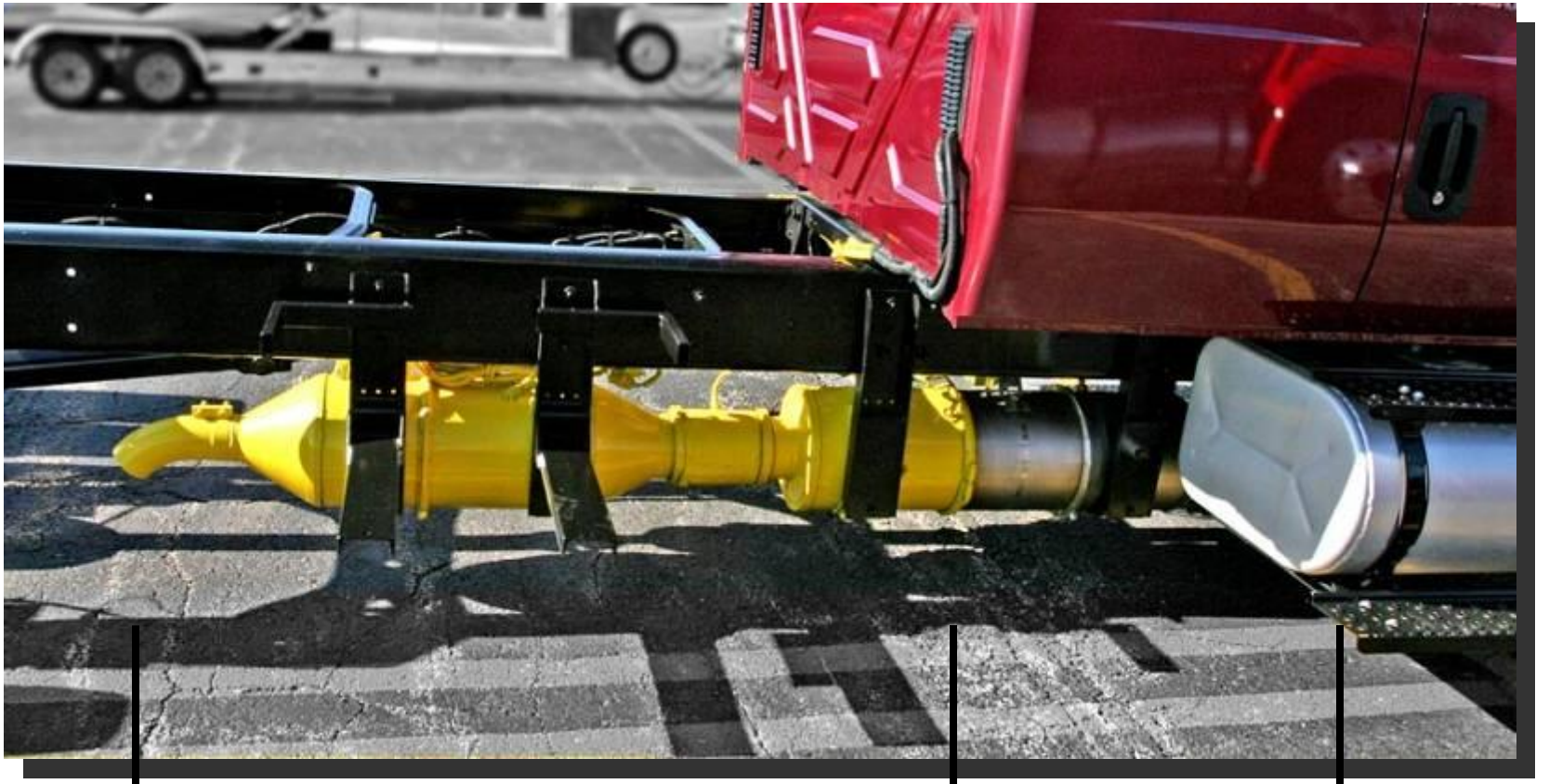
- Known technology for Stationary Power Plants (coal, oil)
  - Constant dosing rate
  - Compressed Ammonia (NH3) or Urea
  - Locally stored, easy to refill
  - Can use agricultural grade urea



Typical SCR System



Typical SCR System



2010 SCR System

2007 System

DURAStar

Typical SCR System

Typical SCR System

Automotive SCR Requirements

Urea Solution Purity and Quality

- European standard DIN V70070 which is 50% higher then North America
- Severe fouling of doser, hoses & tank if urea is contaminated
- North American Standard not established yet to date by ASTM
- Agricultural grade urea CANNOT be used!

SCR Performance Issues

- SCR NOx Conversion efficiency
  - Effect of aging on efficiency & stability not established
  - Product has a Self-life "?"
  - Performance severely affected by fuel sulfur content
- **Cold and Hot Weather performance (below 20°F & above 87°F)**
  - **Requires heated (and cooled) hoses and on-board tanks**
- Ammonia slip (sociability)

Commercial Issues with SCR

Significant Economic Changes

Increased Urea Prices

Storage, Handling and Infrastructure Considerations

Impacts on Drivers

- **Production Costs Increasing**
  - Raw Material - Natural gas global prices
  - Process - need for stringent quality control
- **Urea Market Conditions Changing**
  - Initially priced to gain market share
  - Cannot sustain such low margins in the long run
  - Fertilizer demand & prices growing steeply
  - Much more profitable in agricultural markets
  - Varied distribution channels needed

Commercial Issues with SCR

- Significant Economic Changes
- Increased Urea Prices
- Storage, Handling and Infrastructure Considerations
- Impacts on Drivers

- **Assumptions in 2003:**
  - Urea usage 2-5% of the fuel consumed
  - Urea Prices $2.40-$3.70 per gallon, similar to diesel

- **Facts in 2008:**
  - Significant changes in economic assumptions

Comprehensive FEV industry survey (June 2008)
A/T Technology, infrastructure and economics in 2008
Includes Europe and North America
TIAX* **- Formerly Technology & Innovation Group, Arthur D Little**

Commercial Issues with SCR

- Significant Economic Changes
- Increased Urea Prices
- Storage, Handling and Infrastructure Considerations
- Impacts on Drivers

"Urea prices double; could affect SCR market"*

$12 / gal

****Integer Research*** (a London-based benchmarking & consulting firm), Jul 08

Commercial Issues with SCR

Significant Economic Changes

Increased Urea Prices

Storage, Handling and Infrastructure Considerations

Impacts on Drivers

- **Lower Urea Solution Shelf-life**
  - Decomposes rapidly at higher temperatures (105^{o}F) over time
- **Minimal Urea Infrastructure in North America**
  - ***TIAX*** study (2003) cost for distribution channels ($25k-$200k)
  - Infrastructure should have started late 2007-early 2008.
  - Requires insulated tanks and storage facilities
  - No government mandate like for ULSD in North America.
  - Any word from the field?

Commercial Issues with SCR

Significant Economic Changes

Increased Urea Prices

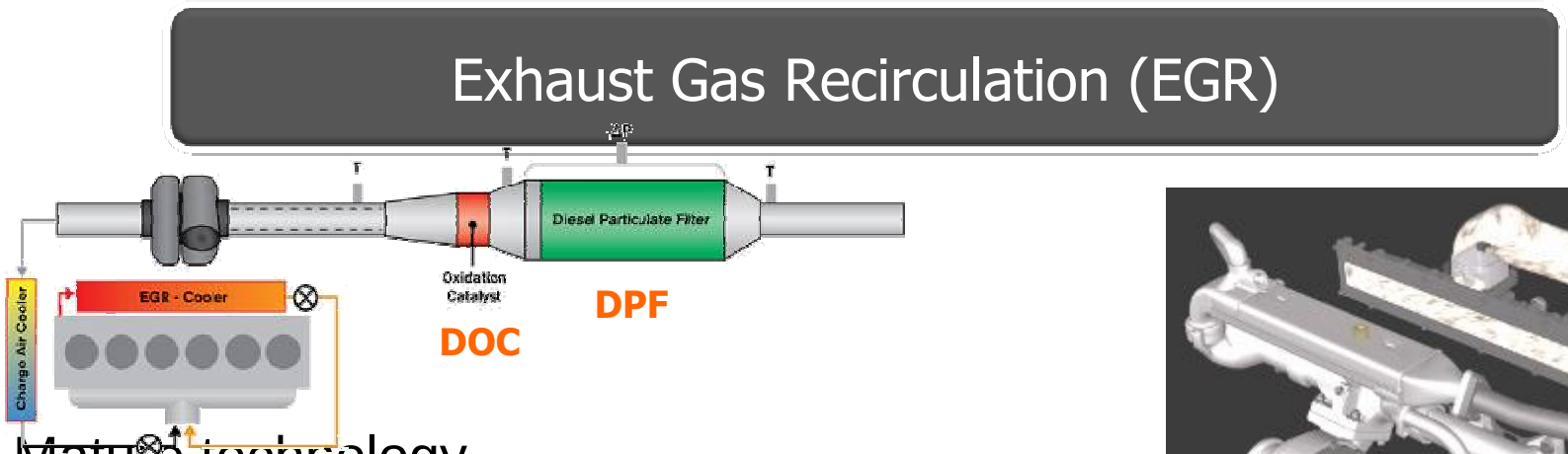
Storage, Handling and Infrastructure Considerations

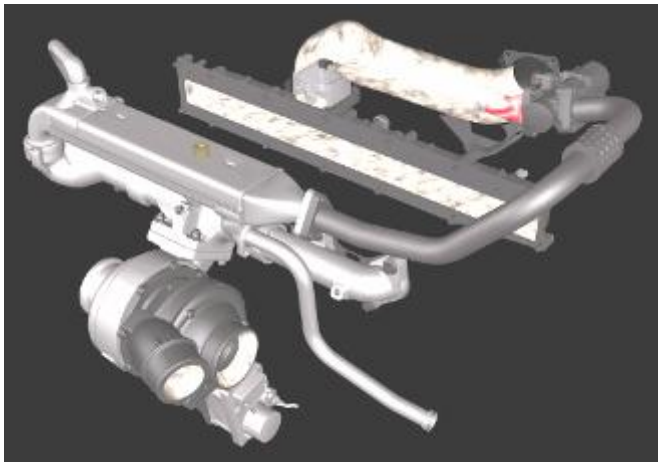
Impacts on Drivers

- **Suggested guidelines (EPA and EMA) to manufacturers**
  - Low Urea level warning light
  - Other messages, lights, etc.
- **Needs Tamper resistant design**
  - Urea tank level sensor
  - Blocked line or dosing valve
  - Disconnected dosing valve, Urea pump, Wiring harness
- **"Strong/Onerous" Inducements to refill urea tank**
  - Disable / de-rate to "limp-home" after fueling, parking or restart

2010 Emissions

Navistar strategy to achieve EPA 2010 compliance





- Mature technology
- Evolutionary change and customer friendly
- Optimized engine and vehicle cooling package
- No adverse economic impact over product lifecycle
- No added weight of additional NOx after-treatment systems
- No added operational, maintenance or serviceability issues
- No added Urea distribution infrastructure concern


HYBRID
TECHNOLOGY
THE HYBRID SYSTEM THAT HELPS
YOU GO GREEN AND SAVE GREEN
Thank You
MILES AHEAD
NAVISTAR®
POWERING INGENUITY